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Science Education

SYMPOSIUM: THE NEED FOR A TWELVE-YEAR SCIENCE PROGRAM FOR AMERICAN PUBLIC SCHOOLS*

I. SOME PROBLEMS INVOLVED IN A PROPOSED TWELVE-YEAR SCIENCE PROGRAM FOR THE PUBLIC SCHOOLS

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The proposal for a complete twelve-year program of science instruction extending through the school system from grades one to twelve received considerable impetus from the report of the Committee of the National Society for the Study of Education, published as the 31st Yearbook, Part I, *A Program for Teaching Science,* in 1932. Since, other committee reports and several state curriculum revision projects have favored such a program.

This report of the National Society is fairly typical of a number of such reports prepared by committees primarily concerned with some one particular area of the school program. Similar reports have been made by interested groups in such other areas as English, mathematics, social studies, modern languages, and industrial arts. These reports have the virtue of striking much nearer the centers of interests of teachers of the subjects represented than many more general treatments. They also present more concrete and more directly usable suggestions than do most other publications dealing with curricular content. This is particularly true of the various reports of the National Council of the Teachers of English, and rather less true of the reports of groups in social studies and in natural sciences.

In nearly all such reports the controlling group is committed to a complete program of instruction running through the whole school system within the area concerned. Thus, we have proposals for twelve-year sequences of instruction in English, social studies, mathematics, natural science, foreign languages, music, and art, in addition to whatever else may be going on in the way of curricular or extra-curricular programs in the same schools and at the same time that these twelve-year sequences are in operation. Is it possible that all of these proponents of twelve-year programs are right? Are the science people more nearly right than the others? Should general education consist of three of these programs, and the others be pruned? Or, is it possible that each such report has been concerned with a relatively narrow presentation of wishful wanting on the part of teachers primarily interested in only one phase of the training of young people? If any program is to be reduced, let it be the other fellow's.

What we have tried to indicate is that any sequence of training representing only one area in a total program must be considered ultimately in its relationship to the total. No one group can set up a tenable program without first finding where such a program will fit into the whole picture of the education of young people. It is

* Presented before the American Science Teachers Association, Indianapolis, Indiana, December 30, 1937.

entirely probable that no single group representing only one general area, such as science, can set up a workable program. Such a group must work in cooperation with others, and also with those people who attempt to see the school situation as a whole.

It is just as sure that no group of generalists can set up successfully the details of a program in such an area as science without the aid of people with training and experience within the science area.

A science program, twelve-year or otherwise, must fit into the working realities of an existing school system. Before such a program can be established satisfactorily certain pressing problems confronting education in general will have to approach solution. Consider for a moment these questions as concerning current secondary education.

1. To what extent shall secondary education be general education?
2. To what extent shall secondary education be considered with college preparation?
3. Can sound general education for the typical "consumer" be made to serve the purposes of college preparation?
4. Of what does the socially desirable general education consist?
5. How much time in the education of an individual shall be devoted to general education?
   a. Can general education be completed by the end of the folk school; *e.g.*, the six-year elementary school?
   b. Can general education be completed by the end of the junior high school, or in 8-4 systems by the end of the tenth grade?
   c. Shall general education for the majority extend through the senior high school?
   d. Shall general education for the majority extend through junior college.
6. What opportunities for specialization are to be offered in senior high school and junior college?
7. Shall opportunities for vocational education be widely offered in senior high school and junior college?
8. If opportunities for vocational training are to be offered in secondary schools, what range of vocational opportunities are to be covered?

These are some of the crucial problems confronting those of us interested in American education today. For none of them is there agreement upon a satisfactory solution upon which we can build a working structure of training for young people. How can we fit a program of science teaching into a system of education unless we know what the system is going to be?

For those interested in science education, let us raise some more specific issues growing out of these general considerations.

1. What contributions can materials, methods, and attitudes drawn from the sciences make to the general education of the vast majority of young people who will never be science specialists in any sense?
2. Can "consumer science" meet the educational needs of the vast majority of young people?
3. At what point in the general education of the majority of young people can the socially necessary science training be completed?
4. Shall college preparatory science be differentiated from science for the purposes of general education?
5. Can the formal science training of most people be completed by the end of the junior high school, or the end of the tenth grade in 8-4 school systems?
6. How much of scientific development and achievement is to be taught in social studies courses?
7. How much of the social and economic consequences of scientific development should be taught in science courses?
8. Are science and mathematics courses to be integrated? If so, what objectives in the training of young people are to be served by such an integration?
9. What opportunities for specialization in science are to be offered in senior high school or in college?
10. Shall courses in applied science closely allied to trade and vocational training be set up in the secondary schools?
11. Is a course in general physical science desirable for general training in the senior high school? If so, is the completion of this course, following the course in general biology, to complete the science training of most pupils?
12. What is to be done with courses in the special sciences that are now commonly taught in the senior high school?
13. What is to be the relationship of a generalized program of science training in senior high school to the science program of the junior college?
14. How is the science program of the junior high school to differ from the proposed science program for the intermediate grades of the elementary school?

Underlying these obvious current questions, confronting the constructors of science programs, are certain basic problems, for the most part, unsolved. The solutions to these problems will, in all probability, serve as determiners of the nature of the science programs of the schools of the future.

In the first place, we are face to face with the fact that we know relatively little concerning the psychological factors or the learning processes involved in reaching objectives in science teaching.

A twelve-year sequence implies that it is necessary to allocate certain learning to one year, certain other learning to the next, and so on. Upon what basis are such allocations to be made? There is a considerable dearth of sound experimental evidence on this problem.

It is probable that the range of abilities of pupils within a grade or school year produce so many overlappings with the abilities of pupils within the preceding and succeeding years that separations are futile. One sixth grader may have a science learning ability comparable to the upper half of high-school sophomores. Another sixth grader in the same school may have less science learning ability than the lower half of second graders in his own building.

It may be that all we shall be able to do in such separations of learnings will be to make gross separation of relatively large areas. Perhaps we can distinguish science for second and third grades from that for fifth and sixth grades; or, junior high-school science from senior high-school science. If this latter solution be true, what becomes of a twelve-year program?

A popular proposal for the separation or placement of science materials in a continuous program is to base such placement upon a pattern of major generalizations in science. It seems perfectly clear that the determination of basic scientific generalizations is arrived at by analysis of the subject matter in question, and not by a study of the learning of young people. Therefore, a list of such generalizations does not determine the sequence of content of courses to be set up in a school program.

The next proposal is that most, or all, such basic generalizations be taught at every level; that is, in every year of a science program; and that the difference from one year to the next be made in an enlarging understanding or interpretation of these same generalizations from year to year.

If we accept this, we are back to the original problem. Just what are to be the understandings of generalizations for a particular grade. Just what difference in the enlargement of an understanding is to be taught in the sixth grade and what in the ninth grade? Please note that now the emphasis is upon understandings rather than upon the verbal statement of generalizations as such.

The listing of important basic generalizations is useful to the course builder and to the teacher as a check list to determine just what science is being taught in a given amount of assimilative material. This is true in spite of the fact that the various existing lists may be incomplete and some of the items included poorly stated. This is true, also, despite the fact that most such lists include some statements that apparently have no meaning at all.

Such lists of generalizations do not, in and of themselves, determine the order and placement of teaching materials in science. Neither can they be taught to children or high-school pupils, merely as statements of generalizations. Such abstractions must be worked over into meaningful assimilative experiences of young people. This implies a considerably extended study of the learning of science materials, methods, and attitudes, going beyond any accumulated body of facts about such learning which we now have.

There is at least another possible method of attack upon the question of placement within such a sequence as the proposed science program. This is to set in motion

a series of investigations of the pressing needs of people at various levels of maturity that could be met by certain scientific informations, by methods of solving problems, or by the acquiring of certain attitudes. The criteria for allocation in this case would be drawn from the determiners of social desirability or need, and not from within the subject-matter of science. The accuracy of solutions chosen to meet the needs of people of different maturity levels would be determined by canons from within the sciences. Some studies from this point of view are available, but not nearly enough to enable us to set up a whole science program for the schools upon the findings.

Another psychological problem confronting the proponents of a science sequence is that of the relationship of the relative maturity, and consequent readiness, of individuals for learning in terms of certain objectives for science teaching. Especially important in this connection are questions dealing with the degree of maturity necessary for developing various specific understandings, methods of problem solving, and scientific attitudes.

Bedell's study[1] of the extent to which ninth-grade pupils are able to make inferences from certain science principles taught in definite situations in school is a case in point. Caldwell worked with much the same issue in the tests used in the survey of science teaching in the Gary, Indiana, schools some years ago.[2]

We know relatively little about the degree of maturity necessary to utilize certain types of problem solving, or to accept and interpret certain controlling scientific attitudes. It is possible that some individuals may never be able to make profitable use of some of the material or of some of the methods which we have been hopefully proposing to include in school science courses.

If we can get enough investigation of this latter problem to approach our building of a science program intelligently and scientifically instead of empirically, we may find that certain kinds of science training for most people may well begin in the fourth, the seventh, or the tenth grade, rather than in the first or second grades. It is possible that we might accomplish the needed science training for young people much more economically in a well organized program of three, five, or six years, rather than in a twelve-year program. Or again, it might take a complete sequence or fourteen or fifteen years. So far we do not know.

In addition to the need for these fundamental studies of psychological factors in learning science, there is great need for study of the social uses and implications of science. Undoubtedly, the development of science as such has far outstripped the abilities of the majority of human beings to make use of its findings. The next great stride in science teaching should be the attempt to train the rank and file of people to utilize the opportunities opened by scientific development.

This implies the attempt to set up desirable social standards of achievement for most normal individuals within the sciences. For example, to what extent is it desirable that a layman have information to enable him to care for his own health problems? Is it socially important that an individual be able to determine the fallacies in reasoning in the typical patent medicine advertisement or the announcements of cures claimed in a commercial radio broadcast? To what extent is it socially needful for a ten-year-old to ponder the emptiness of such a statement as, "Distances in space seem extremely vast when compared to distances on earth,"[3] or "Civilization is advanced by construction materials,"[4] or "Much knowledge is still unrevealed."[5]

[1] Bedell, R. C. *The Relationship between the Ability to Recall and the Ability to Infer in Specific Learning Situations.* Bulletin, Northeast Missouri State Teachers College, December, 1934, Vol. 34, No. 9.

[2] Caldwell, O. W. *Science in the Gary Public Schools.* General Education Board.

[3] 31st Yearbook of the National Society for the Study of Education, Part I, page 53.

[4] Spears, Harold. *Experiences in Curriculum Building.* N. Y.: Macmillan. 1937. Page 131.

[5] *Ibid.*, page 132.

It should be as possible to develop socially desirable standards of attainment in science as in handwriting, arithmetic, written composition, spelling, or civic behavior. So far, as a group interested in science teaching, we just have not concerned ourselves with this problem.

When, and if, we can determine and set up such socially desirable standards of attainment in science, then we should be able to establish an economical sequence of science training which would enable young people to attain such standards as objectives. This may or may not indicate a twelve-year program.

If all this seems too nebulous and too far in the remote future, what then are we to do in the immediate future? These are suggestions for the next attack. First, set in motion a sequence of studies for the determination of adequate social standards for the science attainments of normal individuals in our complex society. Second, at the same time, continue our investigations of the psychological and learning factors which determine the extent of maturity needed for the learning implied in science teaching objectives. Third, continue studies which may throw light on how young people develop scientific understandings, learn to control methods of problem solving, and acquire scientific attitudes.

In the meantime, the schools must go on. Then, let me set up tentative, or experimental, science programs, some twelve-year, some otherwise, to fit varying school conditions as they exist. Let us try these varying programs under actual school conditions. We must then try to establish improved systems of evaluations to determine the values of the programs tried. Finally, we must report the results of such trials in such a way as to be of benefit to others working in schools under similar conditions. By such an evolutionary process we may attain to a science program in the schools which will meet the needs of the majority of the consumers of the world's science.

II. FROM THE VIEWPOINT OF EXPERIMENTAL SCHOOLS IN CITY SYSTEMS

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We should look toward a twelve-year program of science for the boys and girls in our public schools. And this is the apropos time for all those concerned with the teaching of science, at any level, to have this ideal of a twelve-year science program and to push it to its fruition. These twelve years can advantageously be divided into four cycles as follows:

First cycle, the Primary Grades—consists of Grades 1, 2 and 3.
Second cycle, the Middle Grades—consists of Grades 4, 5 and 6.
Third cycle, the Junior High School—consists of Grades 7, 8 and 9.
Fourth cycle, the Senior High School—consists of Grades 10, 11 and 12.

The reasons for teaching science are the same in each of these cycles. A boy or girl who has studied science should be a different individual from one who has not studied it. His behavior should be different in three major ways:

1. Through an understanding of the forces, phenomena, processes, materials and living things that interact to produce the world in which we live.
2. By development of the scientific attitude.
3. By training in the scientific method of thinking.

In this period of exceeding great change there is need that the rapid progress made by science and the many inventions be understood, at least in part, by our young people of today. Even more important to them, however, is the scientist's way of thinking. Contrast the statements of a scientist and of a politician. The premises of the latter too often are founded on prejudice. The scientist, on the other hand, is

free from prejudice, is openminded and has a great desire to know the truth.

You are well aware that a child should begin these habits of right thinking when it is young and must be given many, many opportunities for repeated use of them. How can one be superstitious if he has had repeated practice in cause and effect thinking?

It is therefore of paramount importance that the science course be carefully planned for children in each of the four cycles. The persons responsible for each of these must not plan irrespective of the others. On each level there is need for a well-balanced, integrated course in science. A course which is a mere collection of facts about such things as bees, beavers, butterflies cannot be justified at any level. Interesting though these facts may be, they are not sufficiently general in their meaning to provide a basis for explaining the world or for solving our everyday problems. When a pupil has finished the elementary school he should have acquired basic understandings in the major fields of science—biology, physics, chemistry, geography, astronomy, geology, etc. If this be done you teachers in the junior and senior high schools need not fear lest the edge of interest and enthusiasm for science be dulled in pupils in these upper levels. Just the reverse seems to be true according to the Director of Vocational Guidance in the Cleveland Schools. In over 1300 personal conferences with students in the high schools he found that science is the most interesting subject studied.

Those of us who are making these courses of study should use the scientific method ourselves. It scarcely seems justifiable that we should strive to get pupils to attack a problem in a scientific way, but ignore it as a method in solving the big problem of what science should be taught at each grade level. It is evident, therefore, that our opinion, unless based on proven facts, is no criterion for determining the answer. But much experimentation must be done to determine the best course in science for boys and girls in the different cycles.

Moreover, it seems that those of us who have the privilege of working in experimental schools, should make these have more of the characteristics of a scientist's laboratory. A school in which the teachers just try something or anything that is different scarcely seems worthy of the name laboratory school. Yet you can find far too many reports of these in our educational literature today.

Suppose, on the other hand, we consider the story that Edison and his assistant tested six hundred materials before they found one that would give off much light when an electric current was passed through it. And think of the improvement that has been made since that first electric light. Probably, though, most of us have tested many times six hundred pupils to see if they understood certain aspects of science. If they did not evidence such understanding, what do we do about it? Do we try to analyze why? Were the concepts too difficult, or can better learning situations be set up through which the concepts can be acquired? There is need for solving many such problems.

In Cleveland, we have an exceedingly advantageous set-up for experimentation with science in the first six years of the twelve-year program. The plan there offers opportunity for both intensive and extensive experimentation. The intensive experimental work has been going on with the pupils in one school for almost ten years. This school is called the elementary science curriculum center. Here the pupils actually have been a dominant factor in the development of our science course of study.

The extensive experimentation has been possible by use of radio lessons going over the air to all elementary schools in the city. For the past four and one-half years radio science lessons have been given to grades 3, 4, 5 and 6. These are not just talks, but are really lessons set up around learning situations. The radio teacher pauses 15, 30

or even 50 seconds to give pupils time to answer questions, to make observations or to perform experiments. Through these lessons we have secured much data on what thousands of pupils can learn in science and some of the best ways in which they can learn it.

The radio has proved an effective experimental tool. It would have taken many more years of work in a few classrooms to have revealed such definite indicators.

I shall briefly list some of the major problems that confronted us and tell you how we have tried to solve these.

How can the difficulty of the science concepts gear in with the abilities of pupils at different grade levels? Just which concepts should be taught in each grade? If you examine many science courses of study for elementary schools you will see that the grade placement of science concepts is often a hit-or-miss process. The concept "air exerts pressure" is found in every grade in several courses. Manifestly it cannot be taught equally well in any grade.

Moreover a science course for children in the elementary school should not state the concepts used in the upper levels. Instead the science concepts should be developed only to the level of understanding of the particular group being taught. We, therefore, analyzed the essential science concepts into their simplest elements and have stated in simple child language the concepts which we may expect a child of a certain level to comprehend. I consider that this is our greatest contribution to the field of elementary science.

For example, take the principle of floating bodies. What phases of this can be understood by children in the primary cycle to answer their oft-repeated question, "Why do some things float on water?" Obviously the principle of displacement is too difficult. Through observing and experimenting they can, however, understand weight, size and shape are three important factors. Some of the concepts we have formulated for this unit are:

Some things sink in water.
Some things float on water.
Heavy things will sink.
Things that are light will float.
Things that are light for their size will float.
Things that are heavy for their size will sink.
Things that have holes will sink when the holes get filled with water.
Things that are hollow will float.
Hollow things are light for their size.
Big, heavy iron boats are hollow and they float.

These simple concepts build up a foundation for the understanding in the upper levels of the Archimedes principle that an immersed body is buoyed up by a force equal to the weight of the fluid it displaces.

Then, too, we have tried to build up certain groups of concepts upon others. For instance, the concept of force is first introduced in connection with a magnet attracting iron and steel. The child can easily see that the magnet pulls the iron and steel toward it, and he acquires the concept that such a pull or push is called a force. Later on in other units he can understand other forces such as gravity making things fall to the earth; moving water pushing things along; and that moving air has force to move things.

The sequence of science concepts has helped in another situation. We found that it was much more difficult to teach the life story of seed plants than it is to teach the life story of insects and amphibians. In fact, it was not easy for children to know what plants are. To overcome both of these difficulties we have a unit for the fourth grade called "How Are the Things of the World Grouped?" This takes anything in the child's environment and divides them into two big groups, living things and non-living things, according to five fundamental characteristics. Do they move, breathe, need food, grow, and make others like themselves? Then living things are divided into two groups—plants and animals. Then similarities and differences in structure determine to which major group an animal belongs: mammal, bird, fish, reptile, insect or amphibian. Plants are also divided into

two groups according to their structure: plants with seeds and plants without seeds. After the study of this unit children really understand what plants are and the life history of seed plants is then easily grasped.

Another big problem upon which we have worked is, How can the nature of the subject matter in science gear in with children's interests? All persons who are connected with the teaching of elementary science soon become aware of the intense pupil interest in the subject. Needless to say, however, they are much more interested in certain phases at different ages.

Some of the techniques we have used to determine these interests are: (1) keeping diaries of classroom happenings in science, (2) tabulating pupils' questions, (3) surveying pupil-interest in the different grades three times each year, (4) considering scientific facts remembered by pupils, and (5) listing materials brought to the classroom by pupils.

But after these pupil interests have been determined how can they be utilized in organizing science units? Instead of building a unit on mechanics around levers, inclined planes and pulleys for children in the second or third grades, why not build it around a paramount interest in how his toys run? Here you find that a spring and gears play an important rôle.

Or suppose you are considering a unit on adaptation for the lower grades, why not use zoo animals concerning which children are not only extremely interested, but also usually well informed? We have a unit called, "How are the animals of the zoo or circus fitted to live in the places they came from?" How these animals are fitted to get food, and to protect themselves serve as clear-cut illustrations of this phase of adaptation.

Just what scientific terminology should be used? With the very young child technical expressions should be avoided. This does not mean that a scientific vocabulary is not to be developed. On the contrary, it is extremely important to build a vocabulary of science step by step. We must remember that terms without understanding becloud an idea, but that terms which are the result of understanding developed through experience serve to clarify the thought.

In one of our experiments the teachers were asked to teach a number of units, omitting scientific terms wherever possible. For example, in the growth of seeds the teachers found that fifth-grade children were not satisfied to call it a baby plant after they had found the word embryo in their reading.

We have also considered certain aspects of children's ability to observe and to experiment. We have analyzed the ability to accurately observe into twelve steps in the order of their difficulty and development. It seems essential that every student of science must acquire these different abilities to observe. In like manner we have analyzed the steps which must be developed in the ability to perform an experiment.

But how can all these factors be put together in a science course of study that will become as a machine working for both the teachers and the children? If we do not have all the parts geared and working together, it is just as if we put the gears, springs and all the inner workings before a boy and told him that the watch would run if put together properly.

To accomplish this in our Cleveland Course of Study in Elementary Science we have organized the material on the unit-problem basis. The content of each unit is focused on the acquisition of general meanings. Through observing, experimenting, other activities and experiences, the child is led inductively toward the understanding of these meanings.

The form of the course is in three parallel columns. In the first the problems are given, and in the second are listed the suggested procedures for solving the problems. In the third column are definitely stated the concepts which the child should acquire through these experiences. You can see

that we have attempted in many ways to get the science content synchronized with the child's interests, abilities and ways of learning at the different levels.

III. FROM THE VIEWPOINT OF COLLEGES TRAINING TEACHERS FOR TOWNS, VILLAGES, AND RURAL SCHOOLS

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It is with some hesitation that one accepts the invitation to discuss from the point of view of teacher training colleges the proposed solution to this problem toward which many of you have made valuable contributions. You will recognize in this discussion gleanings from questionnaires and from your own published studies with, perhaps, a few added suggestions.

IS COMPREHENSIVE PLANNING OF THE SCIENCE PROGRAM NEEDED?

In every field of human endeavor the need for comprehensive planning is becoming painfully evident. The science curriculum is no exception. You are aware of the present state of the sciences in our schools. While much progress has been made, no continuous science program has been developed. In the elementary grades it is rather haphazard. There is little articulation between the science of the elementary school and junior high-school general science. Much repetition occurs in general science, the same units involving similar approach and content often reappearing in the course of study for successive grades. The special sciences of the senior high school are usually elective and, therefore, are not studied by large numbers of pupils. Moreover, the abundant analytical and experimental literature dealing with these problems has glaringly revealed the inadequacies of our present courses to develop in our pupils the eager anticipation, the feeling of sharing in the conquest for truth, the tendency to depend on well-studied experience, and the outlook for controlled existence which are the treasures of science. There is neither time here to review this literature nor to recount the implications of the rapidly expanding science of recent years for enriched existence along all lines. We are here to consider the possibility of bridging what has aptly been termed the widening "chasm" between the vanguard of science and the product of our schools. We face the fact that while science is reshaping every phase of human activity, it holds no such dominant rôle in the American public schools.

The program of studies has grown by aggregation with little evaluation and reorientation. Existing subject fields, such as the sciences, have shown surprising and unfortunate inertia to change. Biology texts, for example, all but omit conservation, and we are seeing that subject matter enter the curriculum as a separate study. Science courses have so generally ignored the primary problems of safety that educators are organizing courses in safety education. There is a growing demand for a course in sex education, but is there a teacher who questions that the natural approach to this problem is through science? The industrial civilization has long left a people, untrained in the scientific understanding of its new acquisitions, to cope blindly with a maze of products for the evaluation of which scientific attitudes and knowledge are sorely needed. One after another a long line of urgent personal and social needs have arisen, impinged upon us, and burned their way into our social consciousness until we can no longer turn a deaf ear to them.

The tendency to expect change as the natural order of things and the ability to function in the face of changing situations and needs is considered one of the impor-

tant outcomes of science teaching. Are we science teachers exhibiting that elastic mental characteristic? Shall we continue in our traditional way while the social studies and extra-curricular activities preempt the school program with, what I believe I am correct in characterizing as, less fundamental and understanding, but more direct, attempts to meet urgent human needs?

HOW GREAT IS THE UNDERTAKING?

The answer to this question is that it is clearly enormous. It is not a matter of adopting a new program as we might select a completed automobile, but rather one of basic planning. The undertaking is vast in many respects. If it is to take root and grow in American schools, it must be of them and by them—not imposed from without, but fabricated out of the contributions of classroom teachers and those educators and scientists who are closest to the schools. Can the more capable and professional teachers throughout the country be aroused to the task? Is it visionary—science teachers of the nation at work on a purposeful and functional program?

The problem is much more than the extension of science instruction. The development of a reasonably effective continuous science program is a vast undertaking involving broad cooperative educational and social planning. It must be based on needs, individual and social, which change with the development of the child and of society. The survey to discover and define the needs, some of which are common to all of our people, some decidedly local in character, must be carried on throughout the country. We have made a good beginning and our duty along this line is clear.

Every need calls for creative thinking to devise hopeful procedures to lead to the desired outcome. In the aggregate, this means a vast literature of richly suggestive procedures designed to meet the needs. These, in turn, must be evaluated as to their effectiveness by the best means of appraisal at our disposal. There are countless problems in determining suggested grade placements, and developing suitable reading materials for the various levels. Perhaps, the greatest problem is the training of teachers, both prospective and in service, for so great a task.

IS THE TIME AT HAND TO LAUNCH THE UNDERTAKING?

The present reorientation in education offers an opportunity and a challenge. It means opportunity for a purposeful twelve-year science program to receive more interested and intelligent consideration than it would be accorded in times of greater curricular stability. Fields are being reoriented, reorganized, combined, discarded, added.

Another evidence that the time is ripe to launch our concerted efforts, lies in the large number of attempts already begun throughout the country to orient science teaching to the needs. The many articles and courses of study which are appearing reveal a growing awareness of the needs and a large number of uncoordinated efforts to meet them. We are attaining the initial stage essential to improvement—awareness of inadequacy and the vision of something more purposeful and functional. We are already entering the second stage of creative activity, and we need to pool our efforts.

In a recent article, Caldwell,[1] out of his perspective, predicts that a plan for coherent and cumulative science instruction will be in general use within that time. Many of us feel that the time is at hand to begin constructive planned efforts in this direction. In this period of general curriculum reorganization it would seem that associations of science teachers ought to institute proceedings looking toward development of a twelve-year science program, and that the efforts of the various groups should be correlated in some way.

[1] Caldwell, Otis W. "The Next Ten Years in Science Education," *Science Education*, 21: 61–64; April, 1937.

ARE SCIENCE EDUCATORS AGREED AS TO THE DESIRABILITY OF A CONTINUOUS TWELVE-YEAR SCIENCE PROGRAM?

No satisfactory answer to this question is available at present. Views relative to the undertaking were elicited from science education workers in thirty colleges engaged in training teachers for the towns, villages, and rural schools. The number is not large, but it includes many of the leading teacher-training institutions in all parts of the country. If the responses may be taken as indicative, there is considerable agreement on this matter among this group of workers. They are virtually unanimous in stating that the present science program in the public schools is not satisfactory. Replies received from members of a local science teachers' organization, all of whom are actively engaged in teaching science in the secondary schools, corroborate. On the question, "Is a continuous twelve-year science program essential to meet the needs?" twenty-four replies expressed the conviction that it is. Four held it to be highly desirable, one preferred complete integration of subjects, and one urged that more attention be paid to science in the first eight grades. So nearly complete agreement among widely separated workers is seldom encountered on any important matter of policy. Whether we shall find science education workers generally agreed after the issue that we are discussing has had wider and more thorough consideration, remains to be discovered.

WILL THE SCIENCE TEACHERS COOPERATE?

One can only conjecture. There are discouraging situations that must be remedied. Contact with the movement is virtually essential for cooperation. Yet relatively few of the thousands of science teachers read the professional literature in their fields of service. They do not subscribe to the magazines in science education and, in most cases, probably do not have ready access to them. Under these conditions the journals have struggled to exist and it is fitting and due that we should credit highly those workers in the field who have, as an added load, borne the burden of their publication. The magazines have been remarkably good, when we consider the conditions under which they have been produced. However, a much greater service to science teachers is possible, as was pointed out in the discussion at a previous meeting of this society,[2] both through increasing circulation and widening the sphere of activities of the publications. If the teachers are to cooperate in developing a Twelve-year Science Program about the needs of individuals and of society, it is highly important that these magazines become the professional press of the movement, and that they be in the hands of the workers.

It is equally important that associations of science teachers become the forums of the movement. While larger numbers of teachers may attend national meetings as professional zeal increases, it is especially important to foster the growth of smaller working organizations of science teachers throughout the country. Recent accomplishments along this line in some states offer great promise.

The forces of nations and of various groups of individuals have been aroused and aligned to other undertakings both social and otherwise. These groups have learned by experience that important bit of psychology that enthusiasm grows with participation. Accordingly they put their members to work. We might well learn from this lesson.

CAN ADMINISTRATIVE COOPERATION BE SECURED?

In the clamor and competition for representation in the program of studies, it is not sufficient that the claimants possess potentialities for human usefulness as the subjects

[2] Glenn, Earl R. "The Need for a National Publication for Science Teachers," and the Discussion by Charles J. Pieper. *Science Education,* 21: 82–87; April, 1937.

have in the past. They must show purposeful design and obvious suitability to meet needs. Educators who determine the school program are broadening in outlook and becoming more discriminative, but few of them are scientists. The proposed continuous Twelve-year Science Program must not only constitute the best instrument to meet the needs that we can devise through our joint efforts, but its social and personal contributions must be so clearly evident that they can be evaluated and appreciated by school executives and educators generally. It must be an instrument that will enlist the enthusiasm and professional efforts of the great host of teachers along purposeful lines. Since individuals and situations differ, it must be richly suggestive, rather than prescriptive, in its approaches.

Administrators are asking us as never before, "What has your curriculum to contribute to a better design for living?" "Will it lead to social outlook and action?" "Will it improve health, safety, and personal efficiency?" "Does it open leisure time avenues of interest and satisfaction?" "Are you teaching isolated bits of information or concepts which help to integrate the individual?" "Are you providing suitable experiences that will develop the scientific attitudes which you claim are important outcomes?" "Have you a rich program to render these desired outcomes functional, or are you basing your claim to a larger share of the child's time on a hope of transfer of training borne of the credulity of your enthusiasm for your subject?" In the crowded program of studies of our changing schools it is likely that the place of the science curriculum will depend upon our demonstrable answers to these questions. In a deeper sense our limitations inhere more in our ability to meet evident needs than in any reluctance of administrators to cooperate. It is true that there are many administrators who evidence little professional zeal or understanding and are chiefly concerned with maintaining an even keel, but most of these eventually follow their more progressive fellows. Fortunately the number of "school keepers" seems to be diminishing rather rapidly. Meanwhile democracy in administration is developing.

WHAT CHANGES IN THE TRAINING OF TEACHERS WOULD A TWELVE-YEAR SCIENCE PROGRAM REQUIRE?

In the questionnaire pertaining to the Twelve-year Science Program that was sent to the teacher training institutions, one of the questions raised was, "What are the chief difficulties that you foresee?" Although a number of possible difficulties were brought out, most of the answers dealt with the problem of training teachers. At the end of the short questionnaire a space was provided for, "Further Suggestions." The space proved inadequate for the splendid suggestions, overwhelmingly devoted to teacher training, that were proffered. It is heartening to read the pages of discerning comments that reveal how much interest and earnest consideration is being devoted to this problem.

What changes in the training of teachers would a Twelve-year Science Program require? One might assume from the question that we have a satisfactory program of teacher training for carrying out the work in science in the schools as it is now organized. Obviously, the men and women engaged in training teachers of science for the schools suffer no delusion. If awareness of our shortcomings offers any basis for future planning, we should have a strong foundation on which to build.

The training of elementary teachers for their work has, in most cases, been both inadequate and unsuited. There is also much discontent with the preparation which the unprofessionalized special science courses have afforded the teacher of general science in the junior high school. The high-school teacher, who has majored in one of the special sciences with a very limited training in the others, frequently

becomes the science teacher. He is then expected to organize his work in terms of the interests, experiences, and needs of the boys and girls. The adjustment is too great for him to make and, too frequently, he settles into the routine of teaching as he was taught.

Recently this situation has received much attention, and steps have been taken to improve it. The problem is an exceedingly difficult one to which no generally satisfactory solution has been found. How can we achieve breadth of training without superficiality? Survey courses may lead to wider perspectives, but they develop very little working knowledge. Can we highly professionalize our courses to enable teachers to direct an active science program at the various levels without sacrificing a more extended science training upon which they will, in countless situations, need to draw?

Although no one is able to prescribe exactly the training needed by those who will teach science, the fact that the lack of suitably trained teachers is, perhaps, the chief factor conditioning the development of a more adequate and functional science program, makes it imperative that we should proceed as rapidly as we can see our way.

The elementary teacher is in most cases a general, rather than departmental, teacher. For this reason the provision for major and minor fields of study, where the practice still exists, should be replaced by a more nearly equal division of time among the various fields. Where this practice has been instituted, elementary teachers are devoting between twenty and thirty quarter credit hours to preparation in science. Along with this practice must go the development of suitable courses to enable her to conduct the work on the elementary level.

Students preparing to teach science at the secondary level will, in most cases, enter the smaller high schools, and be required to direct all of the science work. The development of a continuous Twelve-year Science Program would intensify the need for training in the various fields of science. Accordingly, it seems advisable to replace the various special science majors with a science major in teacher training courses at the undergraduate level. This has been essentially accomplished in a few institutions, but the most suitable major program of this nature remains to be determined.

A greater professionalization of our science courses for the training of teachers at all levels is indicated. The extent and nature of this professionalization, as well as the means of accomplishing it without sacrifice of scholarship and depth of understanding, must be worked out carefully.

Intimate contact and cooperation must be established between the training school and the college division of science. In a minority of our teacher training institutions, notably in certain eastern teachers colleges where instructors at the college level must also teach in the training school, considerable progress has been made along this line. In many institutions there is separation, if not estrangement, and the need is urgent.

HOW CAN OUR EFFORTS TO DEVELOP A TWELVE-YEAR SCIENCE PROGRAM BE COORDINATED?

It is obvious that hope lies in coordinating the efforts of individuals, school systems, science teachers' organizations, and all other forces at work on the science curriculum, and in making their achievements available to others. If all of these organizations were affiliated with the American Science Teachers' Association, it might well assume this function. The affiliation of this society, in turn, with the American Association for the Advancement of Science offers added hope of continued existence and progress. Another invaluable agency in carrying out a concerted attack on the problem now exists in the form of state

units of The Department of Science Instruction of the National Education Association. Our professional obligation to meet the need calls for united action. Discussions of the plans for cooperative action by the various agencies are to be presented by others, and I shall leave further suggestions to them.

HOW COULD A CONTINUOUS TWELVE-YEAR SCIENCE PROGRAM BE DEVELOPED?

The procedure must be planned with great care. It must, above all, be a cooperative plan. In the questionnaire, responses to which form part of the basis of this discussion, three steps in the cooperative undertaking were suggested. They were endorsed, with some added suggestions, by a large majority of the educators who answered the questionnaire. A few workers expressed the conviction that a core of prescriptive procedures is necessary for poorly trained teachers. It was also suggested that strict grade placement may be unattainable or disadvantageous, a view that is in accord with organismal psychology and progressive education. The suggestions for cooperative action are reproduced here for further consideration:

First, Cooperative study and compiling of the needs to be met through science teaching.
Second, Compiling richly suggestive, rather than prescriptive, procedures for meeting these needs.
Third, Assignment of grade placement on the bases of classroom experience, research, and other evidences of suitability.

For want of space, I have necessarily omitted discussion of the researches and other contributions which must serve as vantage ground in the undertaking until we have built better. If this discussion seems to fail to adequately credit what has already been accomplished in science in our schools, it is not for want of appreciation, but, rather, because the need has grown even more rapidly than our achievements. Educational services, administrations, and even civilizations, recede in importance and sometimes cease to exist when they fail to adjust to changing needs.

IV. FROM THE VIEWPOINT OF HIGH SCHOOLS ENROLLING MANY STUDENTS WHO DO NOT EXPECT TO ATTEND COLLEGE

GEORGE L. BUSH
South High School, Cleveland, Ohio

Because of the limitations of my knowledge and teaching experiences, my paper is concerned entirely with the tenth, eleventh, and twelfth grades of the high school. The paper is arranged in five major sections:

1. The case for the non-college pupil.
2. A description of subject material in one organized course for the non-college pupil.
3. Suggestions for courses in two additional grades.
4. Difficulties in the way of the senior high-school portion of the twelve-year program.
5. What the American Science Teachers Association may do in order to help give science its proper place in public education.

1. THE CASE FOR THE NON-COLLEGE PUPIL

You are well informed about the changing population of our high schools, changing because of the addition of large numbers of pupils from that part of our population which was never before represented in so-called higher education. Even in the last ten years our high-school enrollment has kept pace with the increasing population and then has nearly doubled. In our cosmopolitan high schools these pupils have formed crowded classes in woodwork, metal work, automobile repairing, foods, clothing, shorthand, typing and other similar subjects. In many of our cities, special schools are being operated along technical, commercial, and home management lines. These pupils and their parents have not been satisfied with the formal physics and chemistry

common in our high schools. Thoughtful science teachers and school administrators have known for some time that these traditional science courses were not adequately meeting the needs of the big majority of the pupils. The steady drop in the percentage of elective enrollments in physics and chemistry has been further evidence along this line. However, in fairness to physics and chemistry we should remember that this drop is not in numbers but is in percentage and is due to the influx into high schools of pupils who do not fit into the traditional physics and chemistry courses.

Usually when one begins to comment upon the educational needs of our non-college and low ability pupils, a counter argument arises as someone inserts the objection that we must give our attention to the education of our leaders. With that there can be no dispute. Certainly our future leaders deserve every attention that we can give, but the democratic nature of our country also demands well-informed followers. It appears entirely evident that it is not only not economical but not possible to continue to give a leader type of science education to the thousands of future common citizens in our high schools.

If we attempt to determine the needs of high-school pupils by a brief study of the occupations in our world to-day we find that these occupations may be put into three very general classes. There are the occupations which are classed as professions. Among these are the doctors, dentists, nurses, clergymen, teachers, writers, engineers, and research specialists. In general these are the occupations which require extensive education beyond the high school, for which advanced education the high school furnishes the preparation. As you know, it is for some of the professions that the formal and somewhat abstract physics and chemistry have their chief value. Only about 20 per cent of our people are engaged in the professions.

A second group of occupations is generally called the trades. Here are the machinists, plumbers, carpenters, painters, bricklayers, automobile, airplane, and steamship mechanics, printers, stenographers, and farmers. For suitable success these occupations require specialized training along definite lines. Some of this training can be and is given in the high school and some of it must come in special courses beyond the high school or parallel with it. For the trades the traditional physics and chemistry are occasionally desirable but are much less important than they are for the professions. About 25 per cent of our people are engaged in the trades. The remainder of our working people—more than fifty per cent of them, are occupied in what we commonly call jobs. In this group are the railroaders, truckers, bus drivers, general factory workers, operators of automatic machinery, grocery clerks, sales girls, janitors, and homeworkers. Into work of this sort go more than half of our high-school pupils.

Altogether these non-college pupils, who make up about three-quarters of our high-school population and who are to become our common citizens, will spend nearly all of their time and money in the purchase of foods, medicines and clothing, in the construction and equipment of modest homes, in the use of modern appliances for home activities and recreation, and in the enjoyment of the family automobile. It seems highly essential that these common citizens should leave our high schools with an intimate knowledge and appreciation of these things and the part that science has had and will continue to have in the lives of all of us.

Seven per cent of the June, 1937, graduates of the high school in which I am located are now enrolled in college. This school is not a specialized high school. It is a cosmopolitan high school with a definite tendency towards academic subjects because there are located in the same general part of the city a specialized technical high school and a specialized commercial high school. For Cleveland as a whole

about 14 per cent of the graduates now go to college. For the entire country, I have seen variously estimated figures ranging from twenty to thirty per cent. However, it is also well to remember that these figures do not consider at all the appallingly large numbers of pupils who withdraw from high school during the tenth, eleventh, and twelfth years. Surely, science owes to these many pupils who withdraw before their graduation, and to the seventy or eighty or ninety per cent non-college pupils among those who do graduate, something other than college preparatory science.

2. A DESCRIPTION OF SUBJECT MATERIAL IN A COURSE FOR THE NON-COLLEGE PUPIL

In Cleveland we believe that we have one reasonably well-developed course for these non-college or general pupils. This course has been in a process of development for about nine years, and has during the past year, through the publication of a text-book, had a somewhat amazing spread over the entire country. On the whole this course is open to 11th and 12th year pupils who will end their formal education before or at the time of their graduation from high school. We have called the course senior science in order to differentiate it from physics and chemistry and from the usual 9th-year general science course. It is believed that this senior science course accomplishes two things. It furnishes a practical, useful science course for the non-college pupil, and it permits a higher grade of work to be done in the college preparatory classes. Thus the general aim of the course is to give and apply practical information with some of the applications being carried to completion only after the pupil takes his place as an adult citizen in the community. I believe that this kind of a science course is a necessity if we are to hope for a twelve-year science program and if we are to keep step with the most pronounced tendency in modern education—namely, the fitting of the school to the practical needs of the pupil.

This senior science course as we have developed it differs from the usual physics and chemistry in three general ways: (1) It cuts completely across the common subject-matter lines, stressing practical applications rather than the more or less abstract science principles. (2) It aims rather strongly towards giving scientific consumer education, and (3) it directs special attention to the social implications of the subject matter. In discussing these three general differences I want to give several common illustrative examples in order that you may form judgment from numerous actual details of the course, rather than from general theories.

With respect to the emphasis on applications, we have attempted to make the material as useful and practical as possible with little worry over the omission of certain scientific principles which are normally considered indispensable in physics or chemistry or even in the 9th-year general science. Invariably the applications come first, not only in importance but in methods of introduction and presentation as well. If the study of the nature and utility of the electric vacuum sweeper, the electric washing machine, the electric ironer, the electric refrigerator, and the electric mixer lead to an understanding of the electric motor it is considered a desirable but not at all necessary feature of the course. The principles of the electric motor must come last if at all and must be simply expressed.

In the study of the airplane the course emphasizes the use of the airplane in searching for icebergs and wrecked ships, in locating schools of fish for fishing fleets, in the fire patrols of great forests, in sowing rice in water and mud, in fighting insects by spraying poisons, in explorations and exploratory photography, in mail service, and in the increasing general passenger service. Further detailed study

concerns the size and speed of passenger planes, the provisions for safety and comfort, nature and use of the most important among the thirty or more instruments and controls available to the pilot, the careful mechanical inspection, the Department of Commerce continuous dot-dash dash-dot radio beacon which virtually fences in the airplane route when visibility is poor, and the use of air inflation of rubber sleeves on the wings in order to break away ice. Compare the general usefulness, practicality, and interest in this kind of science information with a discussion which emphasizes thrusts, drags, and lifts, combination and resolution of forces, parallelograms and resultants, and you have one of the chief differences between our senior science course and the physics course.

With respect to giving scientific consumer education, it is seldom feasible or desirable or scientific to compare actual brands or makes of important trade products, because the worth of certain brands and makes of products changes so rapidly that the schools cannot continuously give correct information. However, it is quite feasible and desirable to study scientific methods of judging various products, and to show how many of the claims made by advertisers and salesmen are certain to be incorrect. Representative things of a consumer information nature are:

Mineral water does not perform health miracles.

One's beauty is seldom improved by using a particular kind of soap.

Disagreeable body odors are removed by frequent bathing with any good soap.

Certain breakfast food advertising makes roughage unnecessarily important.

Strict flesh reducing diets should be followed only under the careful direction and observation of a physician.

Published testimonials for medicinal preparations are not dependable.

Thread count and length of fiber are highly important considerations in purchasing textiles.

The electrical dishwater is economical only for families of more than six or eight.

When clothes are washed longer than the proper time limit they will actually pick up a part of the dirt again and become less bright.

Plated silver marked grade "A" is actually sixth in value among the ratings generally used for silver.

These few statements illustrate our attempts to introduce at every opportunity consumer information of a practical nature. Through newspapers, magazines, radios, and even house to house campaigns, advertisers in constantly increasing numbers have gone into the homes and touched the lives and habits of the people. It seems entirely evident that educators must learn to be more proficient along these same lines.

Although it is apparent that this consumer education has considerable social value in itself, we have attempted to direct special attention to other social implications of the subject matter. As further illustrations of this social value of science the course considers: The part played by any community in developing a safe and adequate water supply; the effects of weather upon the design of homes, the function of scientific education in insuring the sale of pure foods and safe and effective drugs; the development of good architectural design for homes; community building restrictions; things to think about in buying or building a home; scientific developments with a part in home recreation; factors involved in the selection of a motor car with special attention to second-hand cars; and the entire subject of safety.

The senior science course differs from the general science courses of the junior high school in the fact that emphasis is placed upon things which have greater appeal to the interests of young people approaching maturity—young people who will complete their formal education with high school and who will frequently be making homes of their own a short time later. It is granted that there are occasional duplications between the senior course and the usual general science course of the junior high school. These few duplications are necessary for

proper continuity, and the instructor in each of the few cases aims to make sure that the treatment is not necessarily more difficult, but rather more extensive and less formal than the junior high-school science. One who is inclined to think unfavorably of these few duplications should remember that similar duplications occur between physics and chemistry and junior science. For example, such subjects as the metric system; Archimedes' principle; levers, pulleys and other simple machines; calories; magnetism; batteries; motors; steam engines; telegraph and telephone systems are common both to physics and to junior science. Similarly, such subjects as water purification, oxidation and combustion, composition of air, fuels, foods and vitamins, and production of various metals are common both to chemistry and to junior science. Further justification for this slight repetition is apparent when it is remembered that in view of the important position of science in modern life, there is reason for the repetition in science just as there is reason for the repetition of English in each year, for the repetition of American History in the 11th and 12th year, or for the teaching of arithmetic in the senior high school after it has been emphasized for several years in earlier grades. Such repetition in science is in entire accord, as far as the senior high school is concerned, with the idea expressed in our general symposium topic this afternoon—namely, a twelve-year science program.

In making comparisons between senior science and physics and chemistry it is most emphatically not my purpose to belittle those desirable and highly worth-while subjects. Behind the abstract science principles which physics and chemistry explain and emphasize lie the scientific advances of the future—advances in which the pupils who study only senior science can have no part. Senior science was not designed to replace physics and chemistry but rather to complement those subjects and thereby give valuable instruction materials and inspiration to the many pupils who would otherwise graduate from high school with no science beyond the ninth or tenth year. In Cleveland where, as I indicated, the senior science course has been in a process of developing for some years, it has drawn from physics and chemistry very few pupils, a number of them being pupils who had not been successful in these subjects. By far the greater number of pupils who have taken the senior science course in Cleveland schools would not have taken either physics or chemistry. Some fairly accurate investigations of this fact indicates that only about 12 out of every 100 pupils in senior science would have taken physics or chemistry had there been no senior science. This indicates that the senior science course increases considerably the pupil enrollment in upper grade science. In the two Cleveland schools where the senior science course has been longest in operation and where the physics and chemistry have been elective subjects, the 11th and 12th year pupil enrollment in science has approximately doubled. I repeat, therefore, that the senior science course was not designed to replace physics or chemistry, but was meant to furnish a means of making a form of upper grade science available to more pupils.

3. SUGGESTIONS FOR TWO ADDITIONAL COURSES

As previously indicated the senior science course was designed for use either in the 11th or 12th year. In order to complete a set-up of science for non-college pupils in each of the three years of the senior high school the following suggestions seem to have merit: (1) For the tenth year a biology course to parallel or replace the usual biology now offered. This new biology probably should treat the following general topics: Growing lawns, flowers, common small vegetables, and house plants; diseases and insect pests which affect these plants; prevention or extermination of such household pests as moths, roaches, mice and rats; fine breeding of cats, dogs, rabbits, and canaries; health from the standpoint of

symptoms, recognition, and procedures in connection with the most common diseases. Already we have made some use of such a biology course. (2) For the eleventh year a senior science course similar to that which I have previously described. (3) For the twelfth year an informational science course centered about the most important industries. This course, also, should disregard subject-matter lines in order to emphasize information of a chemical and physical nature about the interesting and practical features of our industries. Naturally the course must not be too technical.

4. DIFFICULTIES IN THE WAY OF THE SENIOR HIGH-SCHOOL PORTION OF THE TWELVE-YEAR PROGRAM

Other groups also with special subject interests promote the teaching of other subjects than science. To illustrate, in Cleveland about three years ago a so-called citizens' committee, disturbed over the social unrest, recommended social studies in every grade. This recommendation later developed into a definite requirement of social studies in three out of the four grades of the high school.

Requirements of the sort just mentioned plus existing requirements in English tend to make practically impossible a third requirement in science and to interfere considerably with a reasonably free choice of electives.

The tendency on the part of pupils towards specialization along such lines as commercial work, automobile mechanics, machine shop, art, home economics, and music adds to the difficulties.

There is only one suitable course available for the non-college and low ability pupils.

Boards of education, school administrators, and the general public (many of whom had to take physics and chemistry against their will) are not convinced that such a program is desirable. In other words science has not yet proved its case by proving its worth to all high-school pupils in each year.

5. WHAT THE AMERICAN SCIENCE TEACHERS ASSOCIATION MAY DO IN ORDER TO HELP GIVE SCIENCE ITS PROPER PLACE IN PUBLIC EDUCATION

This organization may help in overcoming these difficulties by continuing and expanding its efforts to give wide publicity to the interests and accomplishments of science. It appears very certain that science needs the active public support of one or more organizations in order to prevent other groups with other subject interests from hurting the science situation considerably, hurting science not because of any ill feeling towards science but because there is only so much time available in a pupil's high-school life. This meeting being held here with the twelve-year science program as part of the discussion is a distinct and important step in the right direction.

Science must prove its worth for all high-school pupils in every year. This organization can help by interesting itself in courses to be presented for the great numbers of non-college pupils. As the maximum goal attainable, it is more necessary and eminently more worth while to have science courses which attract pupils and please parents because of their usefulness, interest, and general merit, science courses which are elected by nearly all pupils because of recognized value—rather than to have the pressure of requirements which force pupils into subjects. As far as the high school is concerned, no organization and no individual can do more to further a twelve-year science program than to aid in developing science courses of high enough worth to prove their case to our common citizens.

V. FROM THE VIEWPOINT OF THE INTERRELATIONSHIP OF NATIONAL, STATE, AND LOCAL SCIENCE ORGANIZATIONS AND CLUBS

(A)

OTIS W. CALDWELL

General Secretary, American Association for the Advancement of Science

Science could not be excluded from the experiences of young people even if such exclusion should be undertaken. The ways in which it is included in schools, however, may be greatly affected by the attitudes or decisions of those who are responsible. Children and older students have become too alert to scientific affairs to permit success to any effort to restrict their thought about science. When teachers or administrators of a philosophy of education try to bury pupils in linguistic, historic and philosophic matters some of them are sure to emerge with scientific observations, theories about how things work, questions which drive a pure linguist or abstract philosopher to that type of distraction that is too often associated with ignorance. So why not accept the everlasting reaching out of what a noted Indianian, Dr. John M. Coulter, once called "the tentacles of inquiry." Those tentacles will find some way of functioning in at least some of the many manifestations of science. It is through the working of such an attitude of inquiry that much of the present success of science has been achieved, and not primarily because of especially favorable programs of science study.

Great organizations of scientists such as the A. A. A. S., the State Academies, the chemists, physicists, biologists, etc., are not yet fully aware that science education often has been sidetracked by those who might be capable of much help, that is, the scientists themselves. For example, the A. A. A. S. has recently organized a symposium called "Science and Society" and has omitted entirely any topic bearing in any way upon science education. Can those making this program be uninformed or prejudiced regarding education in science? Such an omission may have been caused by lack of knowledge of the importance of the situation or by unwillingness to divert part of their view away from a particular type of interest in science. The A. A. A. S. and the State Academies need to observe their human environment more carefully. The physical and economic environment is clearly recognized. But we urge membership from, but do too little in real cooperation with, those concerned in science education. If we really believe in science education, we must do something about it, more than to ask payment of annual dues to our state and national organization. The A. S. T. A. gratefully acknowledges the cordial and inestimable help from certain outstanding scientists. We trust we may receive the enlarging cooperation of many hundreds of such scientists, not as a favor to a rapidly growing organization, but as a means of caring for the mutual interests of scientists, teachers and the public. Science itself will depend largely upon the continuance and increase of public understanding and appreciation of sciences, and this must include an improved used of science education.

We have reached a stage in science education where we may no longer be complacent with a modicum of success. Our present success is due partly to the unavoidable uses of modern science, partly to the widespread desire to know, and partly to the uncoordinated but valuable results from many educational studies and experiments. We need now to discover, invent, test and validate coordinated procedures which will utilize all the good of recent developments, and look toward a still more effective program. Seventeen years ago, there appeared the

report of a National Education Association Commission on Reorganization of Science in Secondary Schools. That report, by a large and representative committee, recorded the best practices then in use and made certain recommendations. In educational practice, we have already passed beyond most of those recommendations. Other appointed bodies have made other important studies and have published reports much of which are now found in good practice in some schools. Yet we lag in the constancy of science studies throughout the years of the public schools, and much science teaching is still so bad as to be unworthy of science. How can local and national organizations accelerate our improvement?

The American Association for the Advancement of Science has interested itself in these problems. Its committee on the "Place of Science in Education" has stimulated numerous ventures designed to extend and enlarge the effective interest of teachers, pupils and citizens. The conspicuously successful science club movement has grown quite as rapidly as is safe until the necessary teacher sponsorship can be extended. The State Academies of Science have organized and cooperated with Junior Academies, into which many hundreds of individual science clubs, and many thousands of young students have been brought. In some states which have no State Academies of Science, science clubs are fostered by other unusually potent adult organizations, notably the American Institute of New York and more recently the Peabody House of Boston. Local science clubs have given science programs of merit. State-wide programs in Indiana, Illinois, Iowa, Pennsylvania, Kentucky, Kansas, Minnesota, Texas and other states, have been of such scientific quality as to dispel any adult fear that younger people will fail to make good use of such privileges. The Science Fair of the American Institute has become one of the great annual intellectual occasions of New York and vicinity. Parents and other citizens already sense this most unusual opportunity for guiding young people into worth-while scientific work. The publications and radio broadcasts associated with these organizations would have been astounding ten years ago. Yet they are the reasonable and natural product of young minds properly directed.

Such associated organizations are rapidly making our people not only science conscious, but may help toward having us become science-minded. We have heard programs of real merit presented by members of science clubs. We have seen unusual apparatus that was invented and demonstrated by able young people. We have seen science teachers and superior pupils gain renewed confidence and set new goals for themselves through doing together the types of work which call forth their best intellectual efforts. Then, when science clubs initiate new members by proving that breaking mirrors does not bring bad luck; by showing the initiates the wrong of "bearing false witness" against another person; by showing the wrong of making untruthful reports; and by doing no end of other things related to superstitions, to untruths, to false representation, to failure to see the truth; they surely are helping society. Of equally great importance is the opening of engaging intellectual vocations, the development and establishment of truth because it is truth, and making purposeful thinking more widely respectable.

Our science organizations will not of themselves build the desired twelve-year science program, reaching from childhood through adulthood, but they may be of potent assistance to those directly engaged in making that program.

(B)*

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"We now live in the age dominated by the products of science; the age is to come that will be governed by the spirit of science, the spirit of truth seeking," stated Dr. Gerald Wendt, Director of The American Institute, in a recent radio address. It is in this "spirit of truth seeking" that the information in this brief, state-survey report from Oklahoma is presented.

The basis of information is from two main sources: (1) A short questionnaire submitted early in December to 50 leading educators, largely of the state and (2) an intimate contact with educators in the local, district, state, and national organizations for an appreciable time.

The two leading science education organizations in Oklahoma are the Science Section of the Oklahoma Education Association, affiliated with the National Education Association, and the Oklahoma Academy of Science, affiliated with the American Association for the Advancement of Science.

In the Oklahoma Education Association Science Section the attendance may be from 75 to 500. The majority of teachers of science in the state belong and attend these annual district and state meetings. In the state meetings the program usually consists of an outstanding national speaker or a science film, with only occasional contributions from local science teachers.

The Oklahoma Academy of Science membership totals about 350, 44 of these (in December, 1937) being high-school teachers. Twenty-seven of this number were added since December, 1935, due to the interest of teachers in affiliating high-school science clubs. However, the Academy of Science has definitely voted, for the present, to drop this student-centered program, discontinuing the work of the High School Relations Committee with The Association of Science Students of the Oklahoma Academy of Science. Whether these 20 affiliated science clubs will continue as an independent Junior Academy of Science in the state is still uncertain.

The Home Economics Association also sponsors state clubs, with leadership in the State Department of Education. Rural schools have well-planned and well-organized 4-H Clubs. It was mentioned in an interview with a rural supervisor in one of the more progressive counties that teacher tenure is the strongest discouragement to efficiency in the agricultural science education.

A bright side of the science education picture may be found in the work of the Progressive Education Association. This Association held very successful, widely-attended regional meetings in Oklahoma City and Tulsa, in 1936 and 1937. Science teachers have been active in both the national Progressive Education Association and Core-Curriculum experiments.

The background of science education in Oklahoma has been presented that the results of this small, fairly representative survey may be interpreted.

Of 50 questionnaires sent out, 38 have been returned to date. To obtain a view of a large cross-section of science education in Oklahoma, the inquiry was sent to state curriculum chairmen, to Heads of Departments of Education and of Science in the two largest schools, the A. and M. College and the University of Oklahoma, to the seven four-year State Teachers Colleges, and the three leading independent colleges. It was also sent to Superintendents and Associate Superintendents of towns and cities, Deans of Junior Colleges, Principals of small and large Junior and Senior High and Elementary schools, Science Directors, Directors of Reading in Elementary schools,

* Read by title.

County Superintendents and Rural Supervisors, and classroom teachers in elementary and secondary schools. In addition an effort was made to get a representative geographical response from the entire state.

The four questions asked were:

I. Is a 12-year program in science desirable in Oklahoma?
II. Can it be started now with a fair degree of success?
III. What are the greatest difficulties to be overcome?
IV. How may the American Science Teachers Association and the American Association for Advancement of Science assist in giving science its proper place in public education?

There were 339 separate responses classified under fourteen headings according to the educational ranking in the state. Three national leaders of the Progressive Education Association were classified under one heading. Two Texas educators qualified to speak for Oklahoma were placed under teachers colleges and city high schools. Of the total responses, including oral interviews, 39 state a twelve-year program of science between kindergarten and college is desirable, three others responded negatively and four were uncertain. However, under question II, twelve of these were in doubt as to whether this program could be successfully started now, eight were positive it could not be started now, and twenty-five advised beginning at once, although perhaps gradually and slowly.

It may be noted that this questionnaire does not take into account the fact as to whether any school system has a twelve-year program already functioning. It is known that there is one system, and perhaps two, in the state where this may be true, to a degree.

The difficulties with inaugurating such a program were pointed out by 124 responses, under question III, which logically fell into eight rather clearly defined reasons. The four most prominent were given as (1) lack of properly trained or prepared teachers, (2) inadequate type of courses of study and (3) curriculum materials effectively adapted to the grade levels of the students. Ranking closely with these were given: (1) the need of funds for equipment, (2) ignorance and ultra-conservatism of the public and administrators, and (3) prejudice on the part of subject-matter teachers. Least consideration was given to the idea of the overcrowded curriculum.

There were 127 responses under question IV. Five professed ignorance of the information necessary to answer, two contended it was not the duty of the American Association for the Advancement of Science to foster this program in science education, while the remainder of the 124 responses indicated that there was a positive need for an immediate constructive program on the part of these national groups. Suggestions most frequently made were those pertaining to courses of study which "presented subject matter as a tool for teaching desirable social attitudes." This, it was stated in twenty-two responses, could best be achieved by interconferences of all subject-matter teachers. At the same time it was thought necessary to assist teachers to make their proper adjustment to this viewpoint. . . . Of only slightly less importance was the desire for adequate equipment and materials for this unified program. Therefore, a program of publicity by these Associations was advocated, not only for the general public but for educators who were training teachers, administrators of public schools and classroom teachers of all ranks.

The conclusions drawn from these responses may be generally pertinent to the progressive program of both the American Science Teachers Association and the American Association for the Advancement of Science. But without a doubt it challenges the science teachers of Oklahoma, and perhaps all educators, to face the situation squarely. Of especial significance is the fact that whether or not the most noticeable deterrent to progress of science education is the lack of preparation of the teacher, at any rate leaders in science and education believe it to be true!

If it is true, why is it? What can be done about it? If it is not true, it is time, as one college dean stated, "to organize an aggressive campaign on the part of science teachers to make their influence felt in teachers' conventions."

Stimulated by this accusation, these questions regarding teacher-training were propounded to about one-third of those making this statement of need. The answers, when taken with others, will be of possible value as a foundation for teachers willing to assist in raising the standards of education in Oklahoma.

Of wider interest may be the suggestions as to the courses of study most useful in preparing teachers for immediate efficient classroom experiences. Strongest emphasis was laid upon the desirability of every prospective teacher, of any subject or grade, taking courses in general biological sciences, general physical sciences, and a course dealing with the psychological adaptation of the science information. "This," stated one Associate Superintendent of Elementary Schools, "will aid the teacher to recognize the needs of the child, so that the child, himself, may make his own satisfactory social adjustments."

To summarize, if the American Science Teachers Association or the American Association for the Advancement of Science will help formulate objectives, prepare socialized science materials within the scope of the child and get these into the hands of the busy classroom teacher without too much expense and delay, and at the same time educate the over-conservative, or ignorant, administrator, professor of education, subject-minded teacher and the general public, it is certain that the working-togetherness of such agencies will make their expected contributions of science service in a democracy.

(C)

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I. The needs of general education in a democracy have, for a long time, been demanding a 12-year program in science.

II. This demand has not been met and the problem has not been solved; largely, for the following reasons:
   1. Science education has been slow in modifying its compartmentalized structure.
   2. Science education has diffused its energies among a variety of goals and educational outcomes.
      (a) Environmental Interpretation.
      (b) Generalizations.
      (c) Socialized Habits and Attitudes.
   3. Science education has, in general, adopted a controversial attitude toward other subject matters, competing against these other subjects for a place in the sun.

III. In the meantime, at least two movements have been developing which may take the solution out of our hands—certainly they change materially the situation which now confronts us.
   1. Science education for the non-academically minded pupil—leading to vocational rather than general education.
   2. Extra-curricular activities for the pupils with special science interests.

IV. Despite the contention of the so-called "progressive" education movement, there will continue to be a sharp distinction between the curricular and the extra-curricular in education.

* Outline of address presented.

1. Teaching large groups of children makes attention to individual differences very difficult.
2. Large and complex school organizations find it necessary to standardize a sequence in curricula and courses of study.

V. A number of agencies have been contributing to science education on the extra-curricular level:
1. The volunteer teacher.
2. Museums.
3. Radio.
4. Newspapers and magazines.
5. Institutions, such as:
   (a) The American Institute of the City of New York.
   (b) The Franklin Institute of the City of Philadelphia.
   (c) The A.A.A.S. Academies.
   (d) etc.

VI. Fullest use of these contributions has been somewhat handicapped by:
1. Heavy teaching load.
2. Lack of facilities.
3. Poor teacher-training.
4. Lack of recognition.
5. Lack of funds.

VII. The American Institute techniques with Clubs and Fairs have served with increasing adequacy to focalize extra-curricular activities in science.
(a) For a local area, closely knit geographically.
(b) For a small portion of the school population.
(c) Chiefly for the senior high-school pupils.

VIII. The elementary and junior high-school pupil also needs to be cared for.

IX. There is need for joint action on a national scale.
(a) To consider the problem of general education, in terms of a 12-year program both curricular and extra-curricular.
(b) To formulate a sound educational basis for a plan that will command attention of administrators, boards of education and the layman.
(c) To facilitate the procuring of funds for:
First: A survey of the problem.
Second: The launching of the program.

WHAT IS THE SCIENTIFIC ATTITUDE?*

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Although the general procedure known as the scientific method is used by all sciences, there is, strictly speaking, no one specific scientific method. The psychologist does not use quite the same approach to his problems as the biologist, and the biologist, in turn, employs techniques more or less foreign to the physicist. But whatever the specific method is, each step in it arises from some phase of the scientific attitude. However, it is not conversely true that each phase of the scientific attitude finds expression in some step of a scientific method. For the scientific attitude is concerned with using knowledge as well as obtaining it, and involves tendencies to refrain from certain types of activity as well as tendencies to pursue other types. Thus, while the scientific attitude and the scientific method are definitely related, they are by no means identical.

On the basis of these definitions of attitude and scientific, the following test for the suggestions relating to the scientific attitude was set up.

1. *Can the thing suggested be a mental set?*
2. *Can the thing suggested affect a variety of stimuli?*
3. *Can the thing suggested condition the mind to a certain type of response?*

* Concluded from the January issue.

4. *Can the thing suggested become stabilized?*
5. *Can the thing suggested foster scientific achievement, which includes:*
   a. *Additions to the world's store of organized truth,*
   b. *Addition to the individual's store of organized truth,*
   c. *Use of organized truth as a basis for determining action?*

The test was applied to each suggestion, to determine if it could be an element of the scientific attitude. If all five questions were answered in the affirmative, the suggestion was accepted. Of the original 432 suggestions, twenty were eliminated by the testing process.

The accepted elements were then classified in terms of their common characteristics and arranged in accordance with the relations existing between them. It is unnecessary to describe here all of the common characteristics and relationships used in formulating the final statement, because they are all implicit in the arrangement itself. It might, however, be mentioned that the classification and arrangement of the separate elements was carefully considered, and that the original statement underwent three complete revisions before the following product emerged.

In stating each element, an effort was made to use clear, concise terminology. Because of the fact that there are not separate names available for each of the elements of the scientific attitude, it was necessary to refer to them in terms of their influence on behavior. Hence the word "readiness" is used to introduce the separate elements. "Readiness" is used here to indicate a mental set which inclines the individual to certain types of behavior. Thus the statement, "Readiness to be openminded," might be translated as, "A mental set which inclines the individual to be openminded." "Openmindedness" describes the behavior; "Readiness to be openminded" describes the attitude. The statement follows.

The scientific attitude includes:

I. Readiness to be confident that human intelligence can understand the phenomena of nature, and through that understanding can become able to control the forces of life. This element of the scientific attitude
   A. Consists of
      1. Readiness to be confident that natural phenomena are understandable, which involves
         a. Readiness to be confident that the universe is a self-sustaining unit, which includes
            1) Readiness to believe that there is no supernatural interference in the universe
            2) Readiness to believe that even man is a natural phenomenon
         b. Readiness to be confident that there are orderly interrelations between all natural phenomena, which includes
            1) Readiness to believe that there are reasons for all things, including
               a) Readiness to believe that every event has a natural cause
               b) Readiness to believe that the same cause always produces the same effect
               c) Readiness to believe that consequences can be deduced from or explained in terms of their antecedents
            2) Readiness to believe that recurring sequences of cause and effect indicate permanent general relations which may be formulated as natural laws, involving
               a) Readiness to believe that the truth itself does not change, although our ideas of it may change
               b) Readiness to believe that these laws may be used to accurately predict future occurrences of natural phenomena
         c. Readiness to be confident that these various relations indicate a systematic unity in natural phenomena
      2. Readiness to be confident that human intelligence is capable of understanding natural phenomena, which involves
         a. Readiness to have confidence in sensory data, which includes
            1) Readiness to believe that the world of common sense experience cannot be transcended
            2) Readiness to believe that the objective evidence obtained by observation of the external world is the only dependable source of truth
         b. Readiness to have confidence in human reasoning
      3. Readiness to be confident that this understanding will enable man to gain increasing ability to adjust himself to the forces that affect life, and to gain increasing control over those forces

B. Gives rise to
  1. Readiness to discredit and abandon all beliefs which depend upon supernatural interference or the suspension of natural law, which involves
     a. Readiness to discredit and abandon superstitious beliefs
     b. Readiness to discredit and abandon beliefs in miraculous occurrences
     c. Readiness to discredit and abandon belief in the possibility of getting something for nothing
     d. Readiness to discredit and abandon belief in the innate authority of hunches, first impressions, feelings, etc.
  2. Readiness to accept tested human knowledge
  3. Readiness to deny the possibility of danger in flooding the world with too much knowledge
  4. Readiness to seek personally to understand the phenomena of nature, which involves
     a. Readiness to seek a unified, orderly comprehension of natural phenomena
     b. Readiness to rely ultimately upon individual thinking and independent judgment
  5. Readiness to attack problems with reason, which involves
     a. Readiness to think freely, defying all dogmas, precedents, authoritative dicta and traditions which are not based on reason
     b. Readiness to seek truth through observation, experiment and thinking
     c. Readiness to look for true cause and effect relations
     d. Readiness to use imagination constructively to suggest a variety of hypothetical solutions to a problem
     e. Readiness to test the hypotheses in the hope of developing dependable laws which will solve not only the immediate problem but also other problems of a like nature
  6. Readiness to deny that the status quo or the trend of events are inevitable
  7. Readiness to seek to control human action with persuasion, not with force

II. Readiness to seek true understanding of the phenomena of nature. This element of the scientific attitude
  A. Arises from
     1. Readiness to love knowledge for its own sake
     2. Readiness to be devoted to social service, which involves
        a. Readiness to desire improvement in the status quo
        b. Readiness to seek increasing control over the forces of life, not for the private exploitation of other humans, but for the progressive advancement of social welfare
     3. Readiness to seek personal achievement
  B. Gives rise,
     1. In relation to the phenomena of nature in general, to
        a. Readiness to have broad and versatile interests
        b. Readiness to be sensitively curious
        c. Readiness to attempt the discovery of new knowledge
     2. In relation to specific problems, to
        a. Readiness to make an active attack on the problem
        b. Readiness to be industrious, persistent and relentless in the search for truth
        c. Readiness to overcome obstacles to the discovery of truth, which involves
           1) Readiness to face personal danger in the pursuit of truth with a courageous, adventurous spirit
           2) Readiness to defy intolerance, to cast off restrictions and to think freely in the pursuit of truth
           3) Readiness to sacrifice personal interest in profit, reputation, or even life itself, with an unselfish, heroic devotion to truth
           4) Readiness to disregard any unpleasantness of conditions, processes or conclusions in searching for truth
           5) Readiness to ignore the apparent uselessness of the truth being sought, and to ignore the lack of assured material reward for its discovery
        d. Readiness to attempt to improve the methods of obtaining truth
        e. Readiness to record and openly publish all discoveries and developments so that they may make an unselfish contribution to scientific advancement and social progress
     3. In relation to scientific achievements, to
        a. Readiness to consider the disclosure of truth to be the greatest of all achievements
        b. Readiness to respect and admire those who have contributed to the disclosure of truth

III. Readiness to seek correctness in work and thinking so that truth may be discovered. This element of the scientific attitude includes
  A. Readiness to seek specific training for any observing, experimenting, thinking, or other operation necessary to the discovery of truth
  B. Readiness to seek a factual basis for all conclusions, and to avoid assertion. This involves
     1. Readiness to distinguish between facts,

which correspond to objective reality, and fancies
2. Readiness to investigate and gather evidence, which includes
   a. Readiness to observe and to experiment
   b. Readiness to read reports of similar investigations to acquire the data that others have gathered
   c. Readiness to recall pertinent information out of all previous experience
3. Readiness to examine and compare the data, which includes
   a. Readiness to pick out essential elements in the data
   b. Readiness to discover similarities, dissimilarities and exceptions in the data
   c. Readiness to determine what conclusions may be derived from the data

C. Readiness to be carefully and painstakingly accurate in all work and thinking, which involves
1. Readiness to define the problem
2. Readiness to observe accurately, which includes
   a. Readiness to control the conditions under which observation takes place, including
      1) Readiness to isolate the facts to be observed, removing irrelevant objects and distractions
      2) Readiness to avoid complexity and brevity in the events observed
   b. Readiness to observe minutely
   c. Readiness to use mechanical aids to extend the range of observation
   d. Readiness to use measuring instruments to improve the precision of observation
3. Readiness to experiment accurately, which includes
   a. Readiness to plan and execute the experiment rigorously and carefully
   b. Readiness to control all conditions
   c. Readiness to permit only one variable
   d. Readiness to use control experiments
4. Readiness to think accurately, which includes
   a. Readiness to think logically, involving
      1) Readiness to use sound, pertinent and adequate data in making inductions
      2) Readiness to follow rules of logic in making deductions
   b. Readiness to think objectively, which involves
      1) Readiness to avoid rationalization
      2) Readiness to avoid wishful thinking
   c. Readiness to think deeply, which involves
      1) Readiness to penetrate external appearances
      2) Readiness to avoid basing conclusions on coincidence
      3) Readiness to avoid basing conclusions on superficial analogy
   d. Readiness to think coldly, which involves
      1) Readiness to be impersonal and disinterested in thinking
      2) Readiness to be unemotional, dispassionate and thoroughly self-controlled in thinking
      3) Readiness to control imagination
      4) Readiness to avoid being swayed by oratory
      5) Readiness to avoid being swayed by the mere novelty or sensationalism of an idea
5. Readiness to calculate accurately
6. Readiness to use words accurately, which involves
   a. Readiness to read carefully
   b. Readiness to choose words carefully
   c. Readiness to define all terms
7. Readiness to be accurate in statement, which involves
   a. Readiness to avoid assertion
   b. Readiness to avoid exaggeration
   c. Readiness to be explicit, not vague
   d. Readiness to use quantitative expression
8. Readiness to record procedures and results to eliminate the inexactness of memory

D. Readiness to be orderly in all work and thinking, which involves
1. Readiness to be systematic in attacking a problem, in observation, and in examination of data
2. Readiness to organize data and arrange it cogently

E. Readiness to seek completeness in all work and thinking, which involves
1. Readiness to seek all the facts, which includes
   a. Readiness to observe and experiment extensively and under a variety of conditions
   b. Readiness to read widely
2. Readiness to consider all possible hypotheses
3. Readiness to keep alert for and listen to any suggestions for further observation, experiment, reading or thinking
4. Readiness to persist until an adequate explanation has been discovered, or the whole truth made clear

F. Readiness to avoid needless complexity in conclusions, which involves
1. Readiness to favor the simplest explanation of a phenomenon
2. Readiness to favor the most fruitful hypothesis which, having widest applica-

tion, relates the greatest number of facts to each other

G. Readiness to be openminded, which involves
   1. Readiness to recognize valid new conceptions, regardless of their conflict with tradition
   2. Readiness to prevent any doctrine from becoming a master to thinking

H. Readiness to be intellectually honest, which involves
   1. Readiness to eliminate prejudices, bigotry and bias
   2. Readiness to be convinced by the evidence, which involves
      a. Readiness to admit error when it becomes apparent
      b. Readiness to abandon pet hypotheses
      c. Readiness to change opinion on the basis of new evidence
   3. Readiness to recognize the limits of accuracy, probability of correctness, and significance of all conclusions, including scientific conclusions
   4. Readiness to be humble, which involves
      a. Readiness to recognize the contributions of others
      b. Readiness to recognize the relative insignificance of present accomplishments in comparison with the tremendous work remaining

I. Readiness to check and verify all work and thinking, which includes
   1. Readiness to verify observations, experiments and thinking by repetition and comparison
   2. Readiness to verify deductions by checking them in terms of the rules of logic
   3. Readiness to test hypotheses by applying them to the facts
   4. Readiness to test theories by making predictions on the basis of them and comparing the predicted result with the observed result
   5. Readiness to record and openly publish all discoveries and developments so that they may be checked by others

J. Readiness to suspend judgment until all facts are in and have been considered, which involves
   1. Readiness to refuse snap judgments and hasty generalizations
   2. Readiness to deliberately reflect on the facts
   3. Readiness to be active but patient in attempting to arrive at judgments, neither expecting nor demanding immediate success in attempts to discover truth
   4. Readiness to tolerate and respect another's point of view, pending suitable investigation
   5. Readiness to recognize the tentativeness of all conclusions, including scitific conclusions
   6. Readiness to hold opinions tentatively

K. Readiness to be critical of all work and thinking, which involves
   1. Readiness to examine all work and thinking to see if it has the characteristics of scientific correctness (See section III, divisions A to J above)
   2. Readiness to extend the attitude of criticalness so that it includes self-criticism

L. Readiness to be rationally and impartially skeptical of the products of human work and thinking, which involves
   1. Readiness to be cautious and conservative in accepting conclusions
   2. Readiness to avoid gullibility and overcredulity

Three criticisms of the foregoing statement which may be anticipated are (1) that the definition is too extensive and complex, (2) that the definition is not complete, and (3) that the definition is the product of subjective philosophical speculation instead of objective scientific investigation. In answer to the first criticism, it should be pointed out that extensiveness and complexity necessarily accompany completeness, and that for particular uses where extensiveness and complexity are serious handicaps, they may be remedied by elimination of the less important sub-headings in the statement. The extensiveness of the statement contributes greatly to its value as a guide for the teaching of the scientific attitude. It would be difficult indeed to develop such abstract qualities as openmindedness and accuracy if no specific statements explaining their meaning and application were available.

The second criticism is true to the extent that our search of the literature was incomplete, and to the extent that the literature itself was incomplete in suggestions of possible elements of the scientific attitude. Although considerable effort was expended to make the definition as complete as possible, there will doubtless need to be a number of additions to the statement as further suggestions are made or discovered. We urgently invite anyone who is interested in

this problem of defining the scientific attitude to send us any ideas or information he may possess, to the end that the definition may be made more complete than it now is.

The third criticism is the most serious of the three, but it too can be answered. In the first place, it is not necessarily true that subjective philosophical speculation always leads to false conclusions. In fact, if we call subjective philosophical speculation by another name, reflective thinking, we recognize it as an essential ingredient in scientific investigation. Subjective thinking results in error only when it is bad subjective thinking. It is possible to surround reflective thinking with safeguards of clearness and definiteness which largely reduce the possibility of error. This we have attempted to do in developing the present definition. The possibility that we have not been entirely successful leads us to seek some check upon the thinking we have done. For to check the results of one's thinking is an essential of scientific investigation.

A direct experimental check of the definition's validity would involve almost insurmountable difficulties. It would be necessary to build two tests, the first to measure the extent to which various elements of the scientific attitude are present in an individual, the second to measure scientific achievement as we have broadly interpreted it, and to correlate the scores on the two tests. Not only would the building of the second test present very serious difficulties, but also the intervention of a host of uncontrollable factors would be almost certain to vitiate the results. For scientific achievement is affected by such things as intelligence, training, etc., as well as by the scientific attitude.

There is, however, another type of check which might be used. If another investigator, working independently but following the same general method, were to attempt the definition of the scientific attitude, he would probably not make the same objective mistakes that may have been made in this attempt. Since any errors which exist in the foregoing definition are very likely errors of subjective judgment, his work would provide a check on the definition.

Our definition of the scientific attitude thus has, at present, only the authority of extensive study and careful thinking behind it. The possibility of limitations of its accuracy and completeness have been acknowledged. Although the definition was prepared with considerable care, it is neither hoped nor intended that it should escape further revision. Developed as a necessary preliminary to the teaching of a unit on the scientific attitude, it is presented here for such correction and use as its merit warrants.

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A COOPERATIVE PROGRAM FOR DEVELOPING TESTS OF THE ABILITY TO USE SCIENTIFIC METHOD IN COLLEGE SCIENCES*

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Frequently when the time arrives to give a test in a course the test is prepared or chosen because it contains the content covered in the course. Little or no consideration is given to selecting the test in accordance with the purposes of the course except that it should contain the subject-matter content. As a result the test usually shows the information students have acquired. It does not show what the students have achieved with reference to each of the other important purposes or objectives of the course. There would be little objection to using only an information test if one can reasonably assume that the recall of information is the only purpose of the course or if there is a high relationship between the recall of information and achievement in other important outcomes of the course, and if the tests used do not influence methods of teaching and the kind of course provided, and if the use of test results is merely to rank students for grading. None of these assumptions is tenable.

There is much evidence which shows that teachers are concerned with more objectives than only the recall of information. Smith's study[1] of objectives of college general chemistry shows that general chemistry is taught for a wide variety of purposes. The exploratory study by a committee of the Botanical Society of America on general botany teaching in colleges and universities likewise shows that teachers consider more than one objective of much importance. Many of these are held more important than only the recall of information.

Evidence[2] is accumulating which shows

* Presented at Section Q, A. A. A. S., Indianapolis, December, 1937.

[1] Smith, O. M. "Accepted Objectives in the Teaching of College General Chemistry," *Journal of Chemical Education,* 12: 180–183; 1935.

[2] Tyler, Ralph W. "The Relation between Recall and Higher Mental Processes," Chapter II, in *Education as Cultivation of the Higher Mental Processes.* New York: The Macmillan Company, 1936.

that high achievement in one objective is not indicative of high achievement in another objective and that low achievement in one objective is not indicative of low achievement in other objectives. For example, a good memorizer may be relatively strong in the recall of information but woefully weak in the interpretation of new scientific data. In other words, knowledge of information does not guarantee attainment in other significant outcomes of the course.

There is much evidence[3] which shows that the testing program affects teaching emphasis. Teachers teach and modify their courses to meet the tests that are given and students study for the tests they take. These conditions are especially the case in which teachers are held accountable for the success of their students, as for example when an outside agency prepares the tests. Teaching and studying for achievement in the objectives of the course is a very desirable thing, but it is equally desirable that the tests give evidence of attainment in each of the important objectives.

More and more intelligent teachers are using tests for purposes other than merely grading. They are using tests during the course rather than only at the end, thus enabling them to get more data about their students at a time when they still have an opportunity to modify their teaching on the basis of the needs of the students. They are using appropriate tests to evaluate present teaching procedures, curriculum materials and educational experiences and to evaluate promising new procedures, materials and experiences. Furthermore we have made too little use of tests as a means by which students can find out for themselves the degree of progress they are making toward desirable ends. To do so the psychology of the testing situation will need to be changed. Conditions must be arranged which will lead the students to think of testing, not as a third degree procedure for assigning marks, but as a helpful method by which they can discover with the guidance of the teacher, the ends to which they can profitably direct their attention, and methods for reaching these ends.

The invalidity of the assumptions often made in selecting and giving tests raises a paramount difficulty in the minds of busy teachers who are engaged in teaching a large number of students, interviewing and other educational activities. How can these teachers find time to develop and prepare tests which fit all the important objectives of their courses? How can these teachers become acquainted with the procedures of testing and develop skill in using the procedures? These are large and overwhelming tasks for one teacher working alone. The usual result is that little progress in the improvement of the evaluation program is made. This does not reflect to the discredit of the teachers, however, because they are greatly handicapped in taking the necessary steps.

During the past eight years we have been working on a cooperative basis with various departments at the Ohio State University, with colleges in the state, with the Cooperative Test Service of the American Council on Education, with the Committee on Tests and Examinations of the American Chemical Society, and with interested teachers in the learned societies of the natural sciences, in developing and improving methods of testing appropriate to the objectives with which they are concerned. The important aspect of a cooperative procedure is that it integrates the qualities and abilities of the teacher who knows the subject-matter field and of the test person who supplies the techniques for an effective attack on the teacher's problems of testing. This method of working together toward a common end is helpful in a number of ways.

Formulating and stating the objectives of the course is the first problem encountered in developing and improving methods of evaluation. The objectives are the

[3] McConn, Max. "The Uses and Abuses of Examinations," Chapter IX, in *The Construction and Use of Achievement Examinations.* New York: Houghton Mifflin Company, 1936.

changes in behavior of students which the course is designed to bring about. Formulating the objectives is really a curriculum problem and is a basic aspect of the evaluation program. It is the responsibility of the teachers. The test person may assist in suggesting methods of formulating the objectives. By this cooperative approach, new and significant objectives are brought to light and are suggestive to other teachers.

Statements of objectives are frequently very general in meaning. For example, a very important objective is to develop in students the ability to use scientific method. This objective needs clarification before it is very useful in planning the course, in providing educational experiences and in developing methods of testing achievement in the objectives. By working with others in exchanging ideas and suggestions, the objective can be clarified and analyzed to the point where it is meaningful concerning educational experiences to be provided students and the kinds of student behavior to be evaluated. As teachers stated their meaning of this objective, it became clear that the ability to use scientific method meant more than one type of behavior. Some of the aspects of scientific thinking stated were, becoming aware of problems, analyzing a problem into factors or hypotheses to be tested in solving the problem, testing these hypotheses, drawing inferences from and interpreting data, using facts and principles of one or more science areas in solving problems new to students, and recognizing assumptions underlying conclusions drawn from data.

By cooperatively thinking about and looking for evidence of these objectives, they were clarified further. For example, interpreting data meant, recognizing the limitations of the data in being cautious but not overcautious in interpreting data, avoid going beyond the data and "jumping" at unsupported conclusions. It meant indicating reasonable inferences and hypotheses supported in part by the data and in part by facts and principles of the science. It meant data presented by means of tables, charts, graphs, pictures, and paragraph descriptions obtained by reading and from direct observations. Application of facts and principles meant predicting and explaining a probable solution of a new problem, judging the soundness of a conclusion, and explaining natural science phenomena in light of known facts and principles rather than in terms of superstitious beliefs and misconceptions.

The statement and clarification of objectives have come out of conferences and individuals working together to develop tests appropriate to objectives of concern. Teachers and test persons have contributed and shared in the results of the process. To many individuals this was the first time the objectives were really thought through to see what they mean for teaching and testing. It has been helpful for these purposes and is in sharp contrast to having tests imposed by the administration.

Evaluation is knitted so closely with the curriculum that clarification of the objectives of the curriculum for purposes of evaluation soon raises questions about the kind of curriculum and educational experiences to bring about these changes in students expressed by the objectives. In working on tests for the application of principles, Dr. W. M. Barrows, supervisor of introductory courses in the Department of Zoology at the Ohio State University, raised the question concerning what would happen to the students in their growth toward this objective if each student were supplied with a list of zoological principles considered in the course and a mimeographed discussion of the meaning of principles from the viewpoints of their derivation and application. It seemed to be a promising hypothesis that the procedure would stimulate students' growth in this objective. Hence, Dr. Barrows suggested a study be made to test the hypothesis. Two groups of students representative of the students in the introductory course were arranged and their progress

during the course appraised by the use of tests for the application of principles. It was found that the group who had been supplied with a list of principles and the mimeograph discussion of the meaning of principles made one-third more progress in one quarter than the group without those materials. The judgments of the zoology instructors supported the objective evidence from the study. They strongly felt that the procedure was worthwhile both to the students and themselves. The materials have now been incorporated as a part of the zoology workbook provided for students in the introductory course.

In discussing tests developed by one group of teachers frequently suggests modifications to other teachers for the purposes of their course and also promising tests for objectives heretofore untouched. For example in discussing the proficiency test in the Chemistry Department at the Ohio State University, Dr. Fernelius suggested that besides including test questions of the ability to apply chemical principles and the ability to interpret experimental data, it might also prove to be a good plan to include test questions of the ability to recognize the evidence needed for an experiment to be more conclusive and the ability to distinguish between experimental evidence supporting a theory and assumptions within the theory. After these objectives were clarified in terms of what students can be expected to do to show achievement in the objectives, situations were formulated and the test questions prepared.

Dr. Hendricks, of the University of Nebraska, has been interested in the application of principles objective in general chemistry. With the assistance of test persons, tests for this objective have gone through several stages of development as the meaning of the objective became clearer and clearer. Again this illustrates that interested persons working together is a fruitful method of developing and improving tests.

Another outcome of a cooperative procedure is that of editing tests to eliminate ambiguity and to evaluate the behavior of the students expected on the tests. In preparing the Cooperative Chemistry Tests, the Committee on Tests and Examinations of the American Chemical Society with which we have been working as technical assistants, the test exercises were sent to interested college teachers of chemistry for critical review and for suggestions of improvement. This procedure not only met the purposes for which it was designed but resulted in an unanticipated outcome. It acquainted teachers with promising tests of objectives for which heretofore they had no tests.

As a result of work in improving tests, departments have developed a reservoir of test material. Caution is taken to prevent the file from becoming antiquated and to make it sensitive to new data in science. The exercises are revised from time to time and new exercises added to obtain a more representative sample of test situations. The procedure used is somewhat like this: When tests are to be prepared, teachers consult their file of test exercises for each objective to be tested, select the exercises for a representative sample, and examine each exercise to see if it needs improvement. If it needs improvement, the exercise is changed to correspond with changes in the course and on the basis of previous use of the test. New exercises are prepared for the same purposes and to round out the representativeness of the sample.

The study of tests in relation to the objectives of teaching is beginning to indicate that a single score of achievement is not as useful as a pattern of scores on a series of important objectives, in understanding the student and in helping the student to understand his own achievement and directions in which he needs further assistance. However, if one wants a single

score for some purpose the separate scores on each objective can be weighted according to importance and combined.

Finally, clarification of the objectives in terms of student behavior and a study of situations in which the behavior may be expressed, when carried on among groups of teachers helps to see the course in perspective of larger development of students. We have come to see a course not as an isolated experience, but as an integral part of their broader development. Scientific method of thinking applies not only in one science but in other areas of life activity. The possibilities of control in some areas and the assumptions necessary, place limitations on the rigor with which the method can be used.

SCIENCE CLAIMS IN MAGAZINE ADVERTISING*

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As a possible check on the findings of the investigators for some of the areas of advertising found, the reports upon specific commodities found in the volumes 101, 102, and 103 of the *Journal of the American Medical Association* were listed on cards and classified as was originally done for the advertising claims. Some of the results from this part of the study are quoted in the following paragraphs.

Reports on 309 commodities were listed from this source. These were summarized in a table under two headings, (1) those reported as having no value for the claims made, and (2) those reported as having "some value." Of the 309 commodities, 300 were classified as having no value, and 9 as having some value.

Of the 309 reports, 33 dealt with nose and throat treatments, including those for coughs, catarrh, and influenza. Only one of these was reported as having some value. Eighteen were remedies for skin disorders. None of these had any value. Twenty-two were remedies for indigestion and stomach disorders. None of these were of value. There were 49 rheumatism, gout, and neuralgia treatments with no value. There were 11 hay fever remedies of no value. There were 33 advertised treatments for feminine disorders in this list. Most of these were advertised as antiseptics for "feminine hygiene." None of them were reported as having any antiseptic value for the purpose claimed. Eleven general antiseptics were reported. Only one was indicated as having some value. These are samplings from the more frequently occurring areas in this list. The others have the same general proportionate values.

The samplings from the findings of this investigation indicate the kinds of claims made in advertising and the kind of evaluations of these claims that can be made either by reference to easily accessible scientific literature or by inference from established facts and principles in science. The study also indicates the areas in which the more frequent advertising attacks are made upon the consumer. The areas in which evaluations may be more readily made are also indicated. These areas happen to be those which most intimately and directly affect the immediate well-being of the average citizen. They are concerned with his food, his health, his protection from disease and injury, with his attitude toward the treatment of disease, and his attitude toward the significance of scientific findings in general. Here are rooted too some of the most flagrant cases of failure to use those types of thinking and simple problem-solving that we have been claiming as outcomes of our teaching of the natural sciences in the schools.

What can be done in the school situation to meet this growing problem? For mod-

* Concluded from the January issue.

ern man this is as seriously menacing as the voodooism and superstitious belief in the hocus-pocus of the medicine man was to the savage and the barbarian. Can the teacher of the high-school sciences contribute to the defenses of coming generations of consumers?

In the past we have depended upon transfer, or concomitant learning, to carry the training in thinking acquired in the classroom and the school laboratory into the ordinary out-of-school behavior of individuals. It is quite clear from the extent to which the kinds of advertising discussed here seem to continue to pay that this dependence upon concomitant learning has not had any high degree of success. A more direct attack upon the problem in the school training being attempted would seem to be next in order.

A possibility in such a direct attack would be to frankly bring the advertised commodities into the classroom and attempt to evaluate these by brand name and according to the specific claims made for each. Some of this may be useful, although the teacher who does it may run into obvious social and economic difficulties due to pressure from those financially interested in the sale of the articles in question.

There are some other difficulties with the most direct procedure. There are altogether too many trademarked foods, antiseptics, mouth washes, tooth pastes, soaps, and so on, to permit of detailed treatment of all of them, even over a period of several years through a whole sequence of science courses devoted to nothing else. New ones are constantly coming on the market. New claims are being made. The latest smattering of science on the laymen's part is always being exploited. For example, the vitamin racket is only a thing of the last few years. Old formulas are promoted under new names and with revised claims. Old names are applied to changed formulas. In other words, the most direct attack tends to result in a static training which leaves the individual stranded and helpless with an outworn body of information within a very few years.

There is a third possibility in training which seems just now to be the most promising. This involves two lines of endeavor. Before attempting to proceed with either, we must largely abandon our past dependence upon the discipline of training in a general scientific method, and our accompanying dependence upon the concomitant learning of scientific attitudes and more specific techniques of scientific problem-solving.

The first of these lines of endeavor involves a direct approach in the development of the attitudes involved in situations of the kind produced by the wide-spread advertising of the commodities discussed in this paper. As yet we do not have any very satisfactory analysis of just what these attitudes are. A few suggestions of possibilities may be worthy of trial with high-school pupils.

Much of our current patent medicine advertising centers around the question of the possibility of self-diagnosis. Could something be done with pupils in school toward the development of the attitude that self-diagnosis of one's bodily ills is usually very inaccurate and often most dangerous? The common phenomena called headache might be used as a center of development for this. "Stomachache" offers another possibility.

Something needs to be done with attitudes towards "endorsement" of commodities. Three such attitudes might be expressed as follows: (1) The social prominence, or publicity value, of a person does not necessarily indicate that such a person has any scientific knowledge of a commodity which he uses or purchases. (2) If one is to have faith in the endorsement of an individual for a particular commodity one should know specifically what qualifications the individual may have for making such endorsements. (3) In accepting an endorsement, it should be clear that the person making the endorsement has no direct financial interest in the

sale of the commodity being endorsed. This latter suggestion would bar from immediate acceptance at face value practically all advertising.

The training in attitudes towards endorsements should also tend to make pupils cautious in accepting the endorsements of some organizations with apparently good antecedents, that have recently gone into the endorsing business. Cases in point are the *Good Housekeeping Institute* and the *American Medical Association.*

A second line of approach is that of bringing directly into the classroom consumers' problems of the kind indicated earlier in this paper. In considering these problems, emphasis must be placed upon the method of attack used in reaching a conclusion, and upon the kinds of reliable sources used as a means of checking upon the validity of claims. The pupils being trained must be so taught that they become conscious of the process used in the attack.

If pupils are to make conclusions concerning the value of face creams for feeding the skin, then the process of inference making, from the basic notion that the skin is fed only from the blood stream from within, must be perfectly clear. Considerable practice in making such inferences must be undertaken. The particular commodities used may be various. Learning to deal with the type of situation involved and learning to use the kind of reasoning most appropriate to the case are more important than the exposure of a particular commodity.

Along with this specific and conscious attempt to learn to think in situations raised by problems of everyday behavior must go a continuous experience and habituation in the use of reasonably reliable sources of information. These must be of the kind that the layman can reach quite readily in the out-of-school situation, and must be available and used in the school situation.

Many of these sources are inexpensive and easy to obtain. For example, the whole moth prevention dope racket can be evaluated by reference to Farmers Bulletin No. 1353, *Clothes Moths and Their Control,* available from the Superintendent of Documents at Washington for ten cents. The average layman knows little of such sources and makes less use of them. The only way in which he may be brought to a better use of available information is through training in a kind of problem-solving that will make reference to such sources frequently and persistently.

Our attempts at democratic secondary education tend to raise the standard of living of great numbers of our people. They should be becoming more sensitive to problems of individual well-being and of the welfare of groups. As a matter of fact, the products of our schools are often open to considerable exploitation. In some cases it would seem that a smattering of knowledge in the science field makes people more susceptible to misleading bendings of scientific facts in the direction of sales promotion of advertised commodities. The schools and the popular literature of science have made people vitamin conscious. The advertisers have done the rest.

The defense seems to lie in a type of science teaching intended to build attitudes and to train individuals in definite types of thinking, as suggested above. How capable the rank and file of high-school pupils may be for acquiring such training, no one knows for sure.

It is certainly worth the energy that it might take on the part of high-school teachers to see if a coming generation of high-school pupils might not be freed from the kind of economic slavery into which they are drifting through the abuse of the glimpses of scientific fact now held by members of the populace. The responsibility lies quite clearly before the door of those concerned with the teaching of science to young people who are to become the rank and file of consumers.

Digests of Unpublished Investigations

IMPORTANT ABILITIES AND KNOWLEDGES FOR TEACHERS OF SECONDARY SCHOOL PHYSICAL SCIENCE IN THE USE OF APPARATUS, MATERIALS, AND TOOLS FOR LABORATORY, DEMONSTRATION, AND SHOP

GUYBERT PHILLIPS CAHOON*

UNIT I

Problem.—"To determine important abilities and knowledge in the use of apparatus, materials, and tools for laboratory, demonstration, and shop, needed by teachers of secondary school physical science for working effectively with boys and girls."

Method.—The teachers of science and the student-teachers in the University of California High School were asked to record "the different specific things which they actually did or which it would be desirable for teachers of physical science to be able to do." The list thus secured was supplemented with similar items from the investigator's analysis of a number of textbooks of physics, chemisty, and general science, and of supplementary books. A final list of 325 specific items resulted. This list was submitted to a group of about fifty teachers of physical science and about fifty "supervisors or directors of science in public school systems or in charge of the training of physical science teachers in Universities or other teacher-training institutions." These teachers and supervisors were selected from the membership of the National Association of Research in Science Teaching, the faculties of the thirty schools in the Progressive Education Association Experiment, the membership of the American Association of Science Teachers, the authors of articles appearing in recent issues of SCIENCE EDUCATION, and *School Science and Mathematics,* and outstanding teachers and supervisors known to the writer or his associates. These teachers and supervisors were asked to submit additional items to the list, which they did to the number of only 14. They were requested to check each item as "Very Important," "Fairly Important," "Relatively Unimportant," "Unnecessary," and "Uncertain." Check lists returned by 40 supervisors and 40 teachers were compared. Since the two groups agreed "rather closely as to the importance of the various items," the eighty evaluations were combined. Judgments as "Very Important," "Fairly Important," "Relatively Unimportant," and "Unnecessary," were weighted respectively 3, 2, 1, and 0. Checks in the "Uncertain" column were disregarded. The respective numbers of evaluation who indicated each item as "Very Important," "Fairly Important," and "Relatively Unimportant" were multiplied by the weighted values corresponding to these designations to get a "weighted score" for each of these three judgments or designations. The three weighted scores for each item were then added to get a "total weighted score" for that item.

Findings.—(1) "Nearly all of the 325 items were judged by half or more of the 80 supervisors and teachers as very important or fairly important for teachers of any physical science to be able to do. . . ." About two-thirds of the items

* Unpublished Dissertation for the Degree of Doctor of Education, University of California, 1936.

were given one or the other of these two highest designations by 75 per cent or more of the supervisors and teachers in the two highest columns.

ABILITIES FOR TEACHERS OF PHYSICAL SCIENCE ARRANGED IN DESCENDING ORDER OF IMPORTANCE AS JUDGED BY EIGHTY SUPERVISORS AND TEACHERS OF SCIENCE*

Neutralize acids and bases (as when spilled)
Operate a fire extinguisher
Distill water
Light bunsen burner to prevent shooting back
Make extension cord with socket and plug
Connect voltmeter into a circuit
Read and adjust a mercury barometer
Connect devices in series or parallel
Adjust and repair bunsen burner
Read a hydrometer
Remove glass stoppers which stick
Read and adjust an aneroid barometer
Set up electrolysis of water apparatus
Work with sodium, potassium, phosphorus
Test and replace fuses
Operate and adjust a projection lantern
Repair motion picture film
Arrange and store chemicals
Make bends in small glass tubing
Read weather maps
Treat acid and alkali burns
Read a watt-hour meter
Clean substances with least explosion danger
Care for and store explosives
Connect dry cells for maximum current, volts
Connect wires together
Construct simple mercury barometer
Distinguish + from − on dry cell by inspection
Strike tuning forks
Measure focal length of lenses
Treat minor cuts and wounds
Read gas, water, and electric meters
Read and attach a pressure gauge
Operate and adjust a motion picture projector
Test to determine + (or −) terminal of a dry cell or storage battery
Use tape (friction or electrician's)
Set up a prism and light source to show a spectrum dispersion
Use a tourniquet
Clean lenses
Test a bar to determine if magnetized
"Cut" glass tubing of small diameter
Test to determine if a circuit is AC or DC
Handle and show the properties of dry ice
Treat burns from fire, steam, etc.
Predict general weather conditions for a day or two in advance from weather maps
Make a simple storage cell
Get acids out of carboys
Disinfect wounds
Care for a vacuum pump
Make a wet and dry bulb hygrometer
Use various instruments usually included in elementary weather recording, as anemometer, rain guage, barometer, etc.
Install and connect various types of electrical switches, plugs, sockets, etc.
Store and arrange magnets in laboratory
Measure noise and sound
Test the electrical condition of a dry cell
Connect a storage battery to a charger
Use a battery charger or rectifier
Determine the size of a wire (using wire gauge)
Test storage battery for "charge" or "discharge"
Select the proper kind and size of wire for different common uses—as bell wire, resistances, house wiring, etc.
Set up demonstrations of osmosis
Use such tools as pipe and monkey wrenches
Clean glass
Replace fuse links in renewable fuses
Make solutions for cleaning glassware
Use a glass cutter
Soften hard water
Use and care for microscopes
Make normal and molar solutions
Clean the commutator of a motor or generator
Use metal cutting shears
Connect a relay into a simple electric circuit
Make and operate simple telegraph sounder
Read and use a micrometer caliper
Give treatment for shock and fainting
Improvise a push-button
Remove common stains of various kinds (ink, grease, etc.)
Use a vise
Make and use a "Cartesian diver"
Give artificial respiration
Make and use simple photometers (as shadow, grease spot, etc.)
Make and use pin-hole camera
Remove foreign substances from eyes
Clean and adjust the make and break points on an induction coil
Construct simple hydrometers
Set up a light source having parallel rays (or nearly parallel)
Operate (and use a photoelectric cell)
Do simple blue printing
Use glue
Make and use a manometer (for measuring pressures)
Replace gold leaf (or aluminum leaf) on an electroscope
Test the relative conductivity (or ionization) of solutions
Seal a wire into a glass tube or bulb
Make or improvise a screen for lantern or motion picture projection
Care for a lead storage battery
Refill a motor driven vacuum pump with oil
Make large charts and diagrams (for classroom use)
Make and use a Wheatstone Bridge

* Because of space limitations only the 224 abilities evaluated as "Very Important" or "Fairly Important" by three-fourths or more of the eight investigators are here included.

Do copper electroplating
Read and use a foot candle meter
Make low temperature mixtures
Make and read a model vernier
Operate and adjust a static machine (revolving plate type)
Determine which side of an electric circuit is "grounded"
Stop a hemorrhage
Make and use a "lamp bank" resistance
Charge a 6 volt battery from a 110 volt DC line
Treat nose-bleed
Set up a model of a hot water or steam heating system
Replace washers in water faucets
Clean copper, brass and other metals
Take good pictures (outdoor and indoor) with a camera
Develop and print pictures
Test for common minerals
Connect a magneto to obtain electrical current
"Tin" a soldering iron
Do simple glass blowing
Set up, adjust, and read a spectroscope
Make crystals "grow"
Change the connections of a series wound generator to a shunt wound, and vice versa.
Adjust and repair bells and buzzers
Make a sterilized dressing
Make "bridges" of adhesive tape for temporary treatment of a cut
Set a maximum-minimum thermometer
Operate Geissler tubes
Demonstrate optical illusions
Build a simple one or two-tube radio set
"Fix up" a dark room for photo developing and printing
Use a clinical thermometer to take a person's temperature
Make "smoke" for demonstrations
Regulate a thermostat
Treat for poisoning of various kinds
Read blue prints
Make up and use a first aid packet
Use a blast burner (air and gas)
Prevent "bumping" in rapid boiling
Make "homemade" slides (non-photographic for lantern projection)
Use a gyroscope
Revive a person who is unconscious
Construct and operate a carbon arc light
Magnetize an unmagnetized bar by pounding it when held in the direction of the earth's magnetic field
Connect wires to the terminals of a lead storage battery having no binding posts (as auto battery)
Etch glass
Read and use contour or topographical maps
Read charts showing the magnetic variation over the earth (or a portion of the earth)
Improvise a substitute for a commercial fuse
Construct a model of Hero's fountain
Cut glass tubing of large diameter or bottles by means of a hot wire
Reverse direction of an electric motor or generator
Clean mercury
Use and work with liquid air
Make a model of a pump from lamp chimney and rubber stoppers
Use a hack-saw
Construct and operate a simple crystal (radio) set
Use an oil stone
Use a speed counter
Adjust and operate a micro-projector
Arrange two parallel wires conducting electricity so that they will be attracted or repelled
Change a bell or buzzer to operate as a sounder
Refill a fire-extinguisher
Use a Kipps generator
Make a gold-leaf electroscope
Make bulletin boards
Sharpen wood chisels, plane blades, knives, etc.
Write on glass
Carry and store (for a few hours) liquid air
Use an aspirator
Make electrical condensers and Leyden Jars
Make an induction coil
Make and use a gravity cell or a Daniel Cell
Use a simple planetarium
Use a hectograph
Re-magnetize weak magnets
Make anti-freeze solutions
Take apart and adjust and use wood planes (jack and block planes)
Make a model or demonstration of the important features of common automobile ignition systems
Clean, soften and care for paint brushes
Distinguish between a rip and a crosscut saw and properly use each
Use a photo-electric cell for determining illumination or light intensity
Demonstrate that certain substances other than iron and steel are attracted by magnets
Construct an amateur telescope
Construct a simple electric buzzer
Set up an amateur weather station
Adjust and repair a static machine
Operate an X-ray tube
Construct a simple telegraph sounder
Fill toy balloons with hydrogen
File or grind a screw driver
Make a simple thermostat
Demonstrate some of the effects of ultra-violet light
Bore a hole in a piece of glass
Make blue prints of magnetic fields
Do nickel electroplating
Make and give an emetic
Demonstrate that certain substances are repelled by a magnet
Do elementary wood-working
Make a dipping needle
Make Y-tubes and T-tubes of glass or metal tubing
Distill a small amount of crude oil

Set up apparatus to make visible Brownian Movement
Make an "iceless regrigerator" (cooling effect of evaporation)
Make solutions of different colors by the use of chemicals
Use a Crooke's tube (cathode rays)
Demagnetize anything which has become magnetized
Solder with copper and brass
Connect up intercommunicating telephones
Make and use a color mixer for colored lights
Replace and repair the element in an electric flat iron, heating pad, etc.
Connect up 3-way switches (so that a light can be controlled from either of two switches)
Mix and use paint, shellac, varnish, enamels, etc.
Make an electrophorous
Make a photographic lantern slide
Operate a thermograph (recording thermometer)
Connect up a thermostat to bells, lights or motors
Use clamps—as cabinet makers and C-clamps
Mend broken glass with cement
Make a multi-purpose ammeter-voltmeter from a galvanometer and resistances
Make models of the structure of atoms and molecules
Test for the effectiveness of insulation
Make a simple microphone from carbon rods or other common materials
Use a fluoroscope
Draw in perspective
Use a miter box and make miter joints
Demonstrate the use of lightning rods

UNIT II

Problem.—To determine to what extent beginning teachers of physical science possess the abilities and knowledges determined in Unit I.

Method.—The 224 skills and abilities judged to be most important in Unit I were made into a "Check List of Performance" and submitted to 30 prospective teachers and 30 experienced teachers of physical science, each of whom had had as teaching majors one or more of the subjects of chemistry, physics, or general science. These teachers were asked to indicate for each item whether or not they could perform the task or skill indicated by it.

A battery of 5 performance tests was next designed to test the possession of important abilities in using apparatus, materials, and tools. "For each performance test the necessary (and some unnecessary) apparatus, materials, and tools were directly available in one place on a laboratory table." A special scoring key was devised by first performing the problem and listing for each step the procedure which was considered good technique and practice. These scoring keys were checked by having 3 selected teachers and supervisors observe a number of other experienced teachers "perform" the problems. On the basis of this preliminary tryout and some experience in using the tests, the problems and scoring keys were modified to their final form. These tests, containing each from 20 to 46 specific items of performance, were then administered to 20 experienced and 20 inexperienced teachers of physical science.

Because of the difficulty of constructing, administering, and scoring such tests of performance, the use of this type of test was deemed impractical. Several experiments were therefore conducted in which various types of tests of performance were tried out with groups of experienced and inexperienced teachers of physical science. As a result of these experiments a "Background Inventory for Physical Science Teachers" of 90 items was constructed by combining an information test of the master-list type with a check list of performance. This test was administered to 231 beginning or prospective teachers of physical science and the results were analyzed.

Findings.—(1) With respect to the "Check List of Performance," half or more of the inexperienced teachers admitted that they had not performed 70 per cent, and half or more of the experienced teachers admitted that they had not performed 43 per cent, of the abilities listed.

2. "The data from the five performance tests indicated that both the inexperienced and the experienced teachers of this group received scores which were only about half of the total possible score value," and that only "about half of each group performed properly half or less of the specific problems."

3. The results with the Background Inventory for Physical Science Teachers showed that half or fewer than half the beginning teachers were able to respond correctly to as many as half the items on any part of the test.

UNIT III

Problem.—"To plan a program in which teachers of secondary school physical science may have experiences which will help them to gain needed knowledge and abilities in the use of apparatus, materials, and tools."

Method.—On the basis of the results of the preceding two units and with the use of the various measuring devices and lists of necessary skills, a plan was devised "so as to offer opportunity for students to get experience in the use of fundamental techniques needed in working with apparatus, materials, and tools, and in the using and making of demonstration and laboratory apparatus needed in the teaching of secondary school physical science. The experiences in techniques in this plan include problems in simple glass working, metal working, wood working, electrical techniques, chemical techniques, using of visual aids, and safety and first aid. These techniques are then used in connection with carrying out the problems in the using and making of demonstration and laboratory apparatus. Experience in using and making apparatus involves problems in assembling and constructing apparatus grouped under the headings of gases and liquids, heat, electrical circuits and devices, light and optical instruments, radio, radiations and photo-electricity, and purchasing and storing supplies."

Editorials and Educational News

MODERN TOWER OF BABEL

At the International Conference of the New Education Fellowship, held at Nice in 1932, one of the interesting meetings was devoted to international language. There was unanimous agreement that "one of the greatest handicaps to the promotion of understanding between different peoples and races lies in differences of language."

If the words, "teachers" and "educators" were substituted for "peoples" and "races" in the above quotation, it would be a suitable theme for a science teachers conference. Of course sophisticated modern students of education refer facetiously to new terminology as "patter" and with the contempt of familiarity ornament their conversation with newly learned words. Outside of the classic halls also, when a new word strikes the popular fancy it gains meaning as a rolling snowball gains size. The present irritant is "integration." In calculus, this had, we recall (perhaps vaguely) a well-defined meaning. But the joining of 2 and 3 to make 5 was still called addition even though the dictionary definition, "bringing together parts into a whole," could logically have been applied to such a process. Since the transfer of the term from mathematics to education, integration has been applied to the whole school system, as in Virginia; to the correlation and coordination of two subject fields, as English and science; to the organization of the curriculum in any school about socially important problems; to the organization of the field of science about similar problems; to the fusion of two or more science subjects, as physics and chemistry; to comprehensive examinations covering more than one field and to any association of experiences in the learning process. Altogether a confusion of tongues.

The College Entrance Board says in its Definition of Requirements (1936), "The examination in physical sciences will be based upon a two-year integrated course in physics and chemistry, and in biological sciences upon an integrated course in the biological sciences which will test the student's ability in and grasp of not only biological principles but also the physical and chemical fundamentals." The Thirty-first Yearbook (page 16) speaks of "integration of subjects of study," and in another place (page 60) says, "Learning takes place as a process of integration of the ideas that are products of real experience."

Thus we have the term, integration, taking over the functions of such terms as, articulation, correlation, fusion, coordination, organization, center of interest, association of ideas, and others. It is applied with equal ease to the learning process, the curriculum, special fields of study, individual subjects, or to combinations of subjects or examinations.

Efforts by educational agencies are being made to vitalize instruction and to make the principles learned in school function in out-of-school life. In all of these plans it seems to be assumed that learning is integration of experiences. If this is acceptable usage, why not adopt it. Can we agree that integration shall mean, "the bringing together" of experiences so that larger meanings and understandings are built up? The "whole" which results will be the individual whose "integrated experiences" enable him to interpret his world and to solve his problems. The so-called intergration of subject matter will not of itself result in the integration of the individual life. It is not so simple. Emphasis on inquiry instead of memorization may help; reorganization of courses about

principles rather than about factual headings may help; motivation by, and application to, problems of daily out-of-school life may help; deletion from our science courses of obsolete and non-functional material may help. But no remedy for the present ill of our science instruction will prove to be a panacea just because it bears the label, "integration."

P.S.—It might be a worthwhile project for a representative committee to undertake the annual publication, in representative educational journals, of good usage in educational terminology.

RALPH E. HORTON,
New York City Public Schools

NATURE STUDY AND GARDENING SECTION OF RECREATION CONFERENCE

MASSACHUSETTS STATE COLLEGE AT AMHERST
MARCH 11 TO 13, 1938

Friday, March 11

Afternoon Session—Fernald Hall

Chairman: Walter Harrison, Amherst Nature Club.

2:00 P. M. Registration.

2:15 *The Place of the Natural History Society in Outdoor Leadership in Recreation-Conservation.* Harry C. Parker, Director of the Worcester Museum of Natural History, maintained by the Worcester Natural History Society.

2:40 *Outdoor Leadership in Recreation and Conservation.* Ernest J. Dean, Commissioner of Conservation, Commonwealth of Massachusetts.

3:05 *Playgrounds and the Recreation-Conservation Problem.* A. R. Wellington, New England Representative, National Recreation Association, 739 Boylston Street, Boston, Massachusetts.

3:30 *Public School Education in Outdoor Leadership in Recreation-Conservation.* Miss Dorothea Clark, Supervisor, Elementary and General Science, Springfield, Massachusetts.

4:30 *Conference Exhibit.* Do not miss seeing the Exhibit and Floor Show.

6:00 *Joint Dinner Meeting* with Parks, Golf and Community Planning Sections at Draper Hall. Reservations must be made in advance. Price 75 cents per person. Dr. Russell Bourne of Sheffield, Speaker.

Evening Session—Stockbridge Hall

Joint meeting with Community Planning and Parks Sections.

Chairman: Dr. Hugh Potter Baker, President, Massachusetts State College.

8:00 *Youth Hosteling.* Monroe Smith, National Director, American Youth Hostels, Inc. Illustrated by new films.

8:30 *Address:* Don Tuttle, New Hampshire Planning and Development Commission.

9:00 *The Florida Everglades.* Dr. Harold C. Bryant, Assistant Director, Branch of Research and Education, National Park Service. Chairman, Bird Protection Committee, American Ornithologists Union. This is one of the most important Conservation Measures before the Country.

Saturday, March 12

Morning Session—Fernald Hall

Chairman: Miss Fannie Stebbins, Supervisor Emeritus, Elementary Science, Springfield Public Schools.

10:00 *The State 4H Conservation Club Program.* George L. Farley, State Club Leader, Extension Service, Massachusetts State College.

10:25 *A Geographer Looks at the Recreation-Conservation Problem.* W. Elmer Ekblaw, Professor of Geography, Clark University School of Geography.

10:50 *Nature Leadership in the Organized Camp.* Roland H. Cobb, President, New England Section, American Camping Association.

11:15 *Teacher Training for Nature Leaders.* Mabel E. Turner, Professor of Nature Study, State Teachers College at Lowell.

11:40 *"Jolly July Jaunts"* or Summer Activities at the Children's Museum. Miss Mildred E. Manter, Director of the Children's Museum, Jamaica Plain, Massachusetts.

Afternoon Session—Fernald Hall

Chairman: Dr. G. B. Affleck, Springfield College.

2:00 *Children's Museums, A Means in Outdoor Conservation,* Miss Anna Billings Gallup, Emeritus-Curator-in-Chief, Brooklyn Children's Museum.

2:25 *Land Use and Recreation Conservation.* Dr. Basil E. Gilbert, Director of Research, Rhode Island State College.

2:50 *"Have You Any Sense?"* Henry E. Childs, Instructor of Visual Education, Providence Public Schools and Lecturer on Visual Education, Extension Division of Brown University. Visual aids will be demonstrated.

3:15 *Wild Flower Conservation Work.* Mrs. Robert B. Parmenter, New England Wild Flower Preservation Society.

3:40 *What the Massachusetts Audubon Society Is Doing for Conservation,* Carl W. Buckheister, Secretary-Treasurer. Colored motion pictures of the Plum Island Wildlife Sanctuary of the Massachusetts Audubon Society.

4:30 Conference Exhibit and Floor Show.

Saturday Evening—Jones Library

Chairman: John Randall, Professor of Natural Science, State Teachers College at Fitchburg.

8:00 *Recreational Gardening.* Professor John Randall.

8:15 *Nature Leadership in the Palisades Interstate Park.* Miss Ruby M. Jolliffe, Superintendent of the Camping Department, Palisades Interstate Park Commission; Illustrated lecture.

8:45 *Some Massachusetts Beauty Spots.* Lawrence B. Fletcher. New England Federation of Bird Clubs. Colored Movies.

Sunday, March 13

Morning Session

Local Sermons on the Outdoors (To be announced)

Sunday Afternoon

MAPLE SUGAR PROGRAM

Courtesy of Amherst Nature Club

1:30 *Maple Sugar Exhibit.* Meet at Horticultural Manufacturers Building, Massachusetts State College to see Maple Sugar Exhibits.

2:00 *Roadside Camps* to visit on the Amherst-Sunderland Road. Cooley's Plum Trees Farm (1756). Grim Outfit. George C. Hubbard's Place. Maple products will be on sale at all three camps. Out-of-town visitors desiring transportation should communicate with Dr. Harvey L. Sweetman, President, Amherst Nature Club, M. S. C.

3:00 *Woodbury Trail to Dr. Milton H. Williams' Sugar Camp.* Take right-hand road which follows Woodbury's Brook. One half mile walk. A typical New England Setting. Guides will lead trips in the Sugar Orchard.

5:00 *Sugaring-Off Supper* at Sunderland Community House. Served by the Dorcas Society. On account of limited space (130) tickets must be obtained in advance.

6:30 *Primitive Sugar Camps.* Colored Lantern Slides shown by W. G. Vinal, Massachusetts State College.

ANNOUNCEMENT—WITH APOLOGIES

In the January issue we began a new section of the journal, entitled "Digests of Unpublished Investigations." Dr. Francis D. Curtis has agreed to prepare for each issue one or more of these digests of unpublished doctoral dissertations relating to the field of science education. We are indeed happy to announce this new feature of the journal and are delighted to have the digests provided for publication by one so well qualified as Dr. Curtis has proved himself to be in this capacity. Most of our readers are acquainted with the two volumes of digests prepared by Dr. Curtis in years past.

Our deepest apologies are offered to Dr. Curtis and to our readers for neglecting to make this announcement in the January issue. The Editor's illness and his absence from the office are the reasons for the omission. We beg forgiveness.

ADVANCED PHYSICAL SCIENCE IN LOS ANGELES

Our readers are acquainted with the movement which, in an increasing number of schools, is directed to the substitution of an advanced course in physical science for the separate, special courses in chemistry and physics for students not expecting to go to college or not expecting to offer credit in one of the special sciences as a prerequisite in technical and professional curricula following their high-school work. More positively stated these new courses are designed to serve the purposes of general education at the secondary level.

Those concerned with this movement will examine with interest and profit Publication C–136 by the Los Angeles City School District, under date of September, 1937. The mimeographed bulletin of 55 pages is entitled "Advanced Physical Science—A Laboratory Science for Upper Grades—Teachers' Guide." The general plan for the course is presented in the first ten pages; detailed suggestions for each of the ten areas of investigation in the course are

given in the major portion of the outline. We quote from the Foreword:

> During the past three years a committee of teachers has been actively engaged in the development of a course known as Advanced Physical Science, offered as an elective laboratory science in the eleventh or twelfth year. Development has taken place largely in the classroom, the teachers meeting together regularly to pool their experiences and to discuss instructional plans, materials, and procedures. This monograph presents a composite picture of the work that is going forward under their direction in some eighteen different schools. It is not to be considered as a finished product, but rather as an aid to furthering and expanding the program that has developed to date.
>
> Evidence at hand indicates that this type of study offers considerable promise in meeting the needs of a large group of senior high school pupils of the city. The course is representative of the functional emphasis which is pervading all phases of the senior high school curriculum. It is a recognition of the great need for providing materials and problems which will challenge the abilities and interests of pupils and which will thereby give them a truer understanding of the scientific world of today.

The ten areas of investigation outlined have the following headings: Water, The Earth, The Atmosphere, Astronomy, Fuels, Light, Transportation, Communication, Materials and Processes, Household Equipment. In each area one finds suggestions for problems dealing with various aspects of the area, a list of major understandings sought, a list of scientific principles, and references to books and periodicals.

It has been some time since there has appeared a document in this field which shows so broad a view of the place of physical science in the secondary curriculum, and such a carefully prepared approach to the different areas of the course. More work of this kind will go far in the challenge of the place of separate courses in physics and chemistry for the secondary school which have objectives in harmony with acceptable objectives of general education. Whether or not the course as outlined will succeed in its stated purposes will depend upon the individual pupil and class activities which are really the course for the pupil. A later edition of the outline in the form of suggested observations, experiments, demonstrations, field trips, and other physical and mental activities for the learner would not only be welcomed by a large number of science teachers, but would at the same time give a better indication of the probable success of the course as outlined.

Abstracts

ELEMENTARY SCIENCE

Palmer, E. Lawrence. "Homes." *Cornell Rural School Leaflet* 31: 1–32; January, 1938.

This Leaflet describes homes of some of the animals of the great outdoors—types, construction, life in a home, home sites, importance of homes, home limits, home territory, artificial homes for free wild life, and key to nests of the commoner summer-resident birds of northeastern North America. —C.M.P.

Melroy, Ruth M. "Science—An Absorbing Interest." *Childhood Education* 14: 176–177; December, 1938.

All children are interested in science and to meet this interest in and need for information and understanding of the natural world about them, the District of Columbia Public Schools have developed a course of study in science for the primary grades. The sciences have been divided, from the teachers' point of view, into four large divisions: physics and chemistry, biology, geology and astronomy. Several science experiences are described. —C.M.P.

Duncan, Carl D. "Insects as Enemies and Benefactors of Man." *Science Guide for Elementary Schools* 4: 1–85; October, 1938.

This issue of Science Guide for elementary science teachers discusses: (1) Position of insects in the living world; (2) Insect foods and feeding habits; (3) Insects as food for other animals; (4) Insect food of some common animals; (5) Insects and flowers; (6) Insects of commercial importance; (7) Insects and soil; (8) Insects and decay; (9) Wood-boring insects; (10) Methods of insect control; (11) Curriculum units; (12) Approaches and trends; (13) Culmination of the units; (14) Educational outcomes of the units. —C.M.P.

Graves, George W. "Soil, Its Use and Conservation." *Science Guide for Elementary Schools* 4: 1–54; September, 1938.

The following points are discussed: (1) What is soil; (2) How soils are formed; (3) How soils are named; (4) The erosion problem; (5) Kinds of erosion; (6) Methods of soil erosion control; (7) Agencies concerned in soil erosion control; and (8) A curriculum unit on soil conservation. —C.M.P.

Anonymous. "Communication." *The Instructor* 47: 45–54; February, 1938.

Suggested teaching procedures for teaching this elementary science unit include for each school level: (1) Possible approaches; (2) General plans; (3) Bibliography; (4) Lesson plans, and (5) Activities. —C.M.P.

Connelley, Russell L. "Thomas Alva Edison." *The Grade Teacher* 55: 44, 70–71; February, 1938.

This is an outline unit for the study of the life of a great inventor. —C.M.P.

Anonymous. "Studying the Heavens." *The Instructor* 47: 41–50; January, 1938.

This illustrated elementary science unit includes study material for primary grades, middle grades and upper grades. Problems, three specimen lessons and a bibliography for each of these grades are included. —C.M.P.

SECONDARY SCIENCE

Evans, P. W. "The Al-Chemist." *The Science Leaflet* 11: 28–36; November 4, 1937.

This is one of the most interesting science club programs that the abstractor has happened across in a long time. —C.M.P.

Symposium. "Science Club Number." *The Science Leaflet* 11: 1–39; September 23, 1937.

This exceedingly interesting number discussed: (1) Organizing a science club; (2) Special club activities; (3) Student science clubs of America, and (4) Special programs. —C.M.P.

Welch, George B. "Sources of Electricity." *The Science Leaflet* 11: 14–18; January 20, 1938.

The article briefly traces ideas concerning electricity from earlier days down to the present time. Sources of electricity and its transmission are discussed. —C.M.P.

Wailes, Raymond B. "For a Few Cents You Can Experiment with Gold." *Popular Science Monthly* 132: 98–99, 124–126; March, 1938.

New and fascinating tests with precious metals (gold, cerium and platinum) from common products or from inexpensive chemicals are described in this article. —C.M.P.

Walling, Morton C. "Getting the Goods on Fabrics with Your Microscope." *Popular Science Monthly* 132: 102–103, 131–133; February, 1938.

This article describes the identification of cloth by means of the microscope—preparing the piece of cloth, staining, fiber characteristics. —C.M.P.

EDUCATION

Committee on Social-Economic Goals of America. "The Future of America." *The Journal of the National Education Association* 27: 8–19; January, 1938.

The committee has proposed ten goals which are discussed in this article. The goals are: (1) Hereditary strength; (2) Physical security; (3) Culture—skills and knowledges; (4) Culture—values and outlooks; (5) An active, flexible personality; (6) Suitable occupation; (7) Economic security; (8) Mental security; (9) Freedom, and (10) Fairplay and equal opportunity.

—C.M.P.

CUSHING, BURTON L. "The Laboratory in Elementary Physics." *The Science Leaflet* 11: 25–27, 22–28; November 18, December 2, 1937.

The values and place of laboratory work are discussed in this interesting article. Six important reasons advanced for pupils taking individual laboratory work are: (1) It is interesting; (2) It teaches by the scientific method of learning facts first hand by the observation of results following definite causes; (3) It develops skill in the handling of tools and apparatus which can be transferred to other kinds of manipulation throughout the pupil's lives; (4) It develops powers of careful observation and an analytical mind; (5) It emphasizes the need of great care to obtain accuracy; and (6) It teaches the necessity of absolute honesty in all science with consequent development of ethical character.

—C.M.P.

NEWBURN, HARRY K. "Problems of Science Education at the Secondary Level." *The Iowa Science Teacher* 3: 120–124, 138; December, 1937.

Increases in secondary school enrollment have created many complex educational problems, and not merely the problem of providing the same education for a greater number of persons. The article describes some of these problems. In the state of Iowa in 1934–35 science ranked fourth in number of schools offering such work (98 per cent) and fifth in terms of number of pupils enrolled (55.6 per cent). In specific sciences—General Science led with 81.7 per cent of schools offering and 22.6 per cent of total pupils. Corresponding percentages in other sciences: Physics, 73.7 per cent and 14.5 per cent; Biology, 45.7 per cent and 10.6 per cent; Physiology, 25.7 per cent and 5.5 per cent; Chemistry, 4.5 per cent and 1.3 per cent; Physical geography, 2.4 per cent and 0.4 per cent; and Botany, 1.3 per cent and 0.2 per cent. Zoology, geology, natural science and advanced general science were offered in a few schools.

—C.M.P.

SCIENCE

MAGEE, H. W. "The Toy That Grew Up." *Popular Mechanics* 69: 188–191, 128A–132A; February, 1938.

The development of the gyroscope into the gyrocompass, automatic piloting and recording devices and gyro-stabilizer is interestingly and clearly described. The gyroscope now aids navigation both on water and in the air as a compass, for automatic steering, for automatically recording the course of a ship, for stabilizing ships and airplanes, and to provide a fixed point and an artificial horizon for blind flying. The gyroscopic elements of the directional gyro and the gyro-horizon may be made to operate the controls so as automatically to keep an airplane flying level on a predetermined course. Such automatic pilots, weighing only 60 pounds, are flying airplanes a million miles a month in the United States alone. An unusual use of the gyroscope is to harness it to the drill mechanism when boring for oil to insure straight holes. For each of the applications for the gyroscope cited the article shows how a toy gyroscope may be manipulated to illustrate the principle.

—O. E. Underhill.

ANONYMOUS. "Hunting Oil with Earthquakes." *Popular Mechanics* 69: 194–197, 17A–19A; February, 1938.

A very good diagram shows how seismograph records from artificially stimulated earth vibrations are used to determine the character of underlying earth strata. Recent improvements in such methods of geophysical research have now enabled profiles of sub-surface strata to be mapped to depths of 20,000 feet, twice that of a few years ago. 15 million dollars a year are being spent in this sort of research to aid in the location of oil.

The detecting part of the apparatus, consisting of a coil of wire delicately suspended in a magnetic field, is lowered into a shallow hole in the ground. The earth's vibrations from a charge of dynamite produce an electric current in the vibrating coil which is led by a cable to an amplifying system carried on a laboratory truck. Thirty or forty of these detectors may be laid out in a line one-fourth of a mile long, making a continuous record of the waves of a single explosion. The currents produced, amplified several times, are made to operate a galvanometer or an oscillograph which produces a wavy line photographically on a revolving cylinder which is graduated in units of time.

—O. E. Underhill.

ANONYMOUS. "Two Miles Down for Oil." *Popular Mechanics* 69: 26–29, 146A–149A; January, 1938.

Interesting details are given of the technique for drilling oil wells to a depth of two miles. Extreme care and skill by the drill man is required to drill a straight hole. It may take over a year to drill a two-mile well. A stream of

mud is pumped down inside the drill and flows back outside the drill, raising rock chips and other debris to the surface. If a rock sample is desired a coring tool may be lowered inside the drill to remove a sample without having to remove the drill pipe. The cost of a deep hole may be one-third of a million dollars. Ninety-two and one-half per cent of the oil produced in the United States comes from between 1000–7000 feet, with the 3000–4000 feet level being the most prolific. Only 3–4 per cent comes from below 7000 feet. —O. E. Underhill.

BLAKESLEE, A. F. "Colchicine." *The Teaching Biologist* 7: 52, 61; January, 1938.

Colchicine is a drug that has recently come in for a great deal of attention as an increaser of the number of chromosomes in plants. Its ability to double the number of chromosomes will probably soon be put to practical application. —C.M.P.

Science Service Staff. "Science Progress in 1937." *Science News Letter* 32: 403–412; December 25, 1937.

This issue of *Science News Letter* summarizes the most important advances achieved in various fields of science in 1937. —C.M.P.

THONE, FRANK. "Plants Grow Whiskers." *Science News Letter* 33: 58–60; January 22, 1938.

The article describes recent experiments in plant hormones and drugs as these affect growth, rooting, flowering and seed production in plants. Plant hormones are now being used to make roots form on cuttings of holly, yew, lemon, etc., which ordinarily are very stubborn about throwing out roots. Seedless fruits such as tomatoes are now being produced by spraying the flowers with hormones. Recently the number of chromosomes in certain plants have been increased in number by applying a drug treatment to the plant—and the more chromosomes, the larger the flowers and the larger the plants. These plants also breed true to their new size. —C.M.P.

POTTER, ROBERT D. "Cryptic Number 288 Found Vital Building Unit in the Structure of Protein." *The Science Leaflet* 11: 28–31; January 27, 1938.

Recent research seems to definitely indicate that protein molecules are made up of units of 288 amino acids or some multiple of this unit. This greatly simplifies the jumbled picture of protein structure. —C.M.P.

CHASE, STUART. "Working with Nature." *The Journal of the National Education Association* 27: 38–40; February, 1938.

The writer is the well-known author of *Rich Land, Poor Land.* In this article he points out the necessity of man's working with nature and that the time to commence is now if we are to save and conserve our rich resources for posterity. —C.M.P.

HENRY, THOMAS R. "The Wandering I.Q." *The Journal of the National Education Association* 27: 41; February, 1938.

Ideas of psychologists and educators relative to the stability of the I.Q. have undergone radical changes within the last half decade or so. Dr. Beth I. Wellman at the recent Indianapolis meeting of the A. A. A. S. tore to shreds the current conception of the stability of the I.Q. Experiments definitely prove I.Q. as measured by present tests is a wandering thing. —C.M.P.

FISHBEIN, MORRIS. "Harmonious Hormones." *Scientific American* 158: 86–87; February, 1938.

Hormones are medicine's newest, shrewdest weapon in the battle against human disease and suffering, yet they remain very much of a mystery. The endocrine glands have been compared with an interlocking directorate ruling the affairs of the body. But on this glandular board, unanimity must prevail; if a single dissenting voice is heard, confusion is inevitable. —C.M.P.

COPELAND, ROYAL S. "Protection for the Public." *Scientific American* 158: 88–89; February, 1938.

The author of the proposed new law relating to food, drugs and cosmetics elaborates upon the reasons why such laws are needed to replace the antiquated Pure Food Drugs Act of 1906. Everyone interested in promoting the well-being of American citizens should actively support the passage of the new law. —C.M.P.

RYAN, EDWARD J. "Identification by the Teeth." *Scientific American* 158: 90–91; February, 1938.

This article points out the need for teeth print charts for purposes of universal recording and identification. No two mouths are exactly alike and teeth have individual characteristics. —C.M.P.

RUSSELL, HENRY NORRIS. "Pulsating Stars." *Scientific American* 158: 84–85; February, 1938.

Pulsating stars have long intrigued the astronomer. Why do stars change in brightness, what really happens and why? A star's diameter may rise and fall by as much as 40,000,000 miles and at a rate of 25 miles a second. New data has increased our knowledge but we still have much to learn. —C.M.P.

BURNS, HOMER S. "An Industry on Stilts." *Scientific American* 158: 69–71; February, 1938.

One of the most interesting developments in

modern industry and engineering is described in this article—the building of an industrial city on a useless tidal marsh one foot above sea level. The site is located 45 miles below New Orleans on the Mississippi River delta, four miles from the Gulf of Mexico. The purpose of this city built in mud is the mining of sulfur, found some 1500 feet below the surface. —C.M.P.

POPENOE, PAUL. "The Paranoid Personality." *Scientific American* 158: 74–77; February, 1938.

A paranoid personality is one in which one or more everyday traits are exaggerated. At its roots is an unwillingness to admit inferiority. Don't be too sure you are not included! If so you would have a goodly company of well-known personages such as Carrie Nation, Woodrow Wilson, Napoleon, Sir Isaac Newton, Clemenceau, and many others. The author discusses how to avoid it, how it grows and how to deal with it. —C.M.P.

HARDING, ARTHUR M. "Time through the Ages." *Journal of Calendar Reform* 7: 210–217; December, 1937.

This is one of a series of articles on the scientifisc backgrounds of man's system of measuring time. Dr. Harding traces the evolution of the modern calendar. —C.M.P.

PRICE, WILLARD. "Japan—A Land of Natural Disasters." *Natural History* 41: 7–15, 80; January, 1938.

Japan is probably more sorely harassed by natural disasters than any other country her size in the world. Earthquakes, tidal waves, volcanic eruptions, storms and fire—all combine to make the Land of Cherry Blossoms lead an exciting life. Illustrated. —C.M.P.

New Publications

FLEXNER, JAMES THOMAS. *Doctors on Horseback.* New York: The Viking Press, 1937. 370 p. $2.75.

The subtitle "Pioneers of American Medicine" is more to the point. The lives and accomplishments of the following men are sketched:—John Morgan and William Shippen, both Edinburgh graduates, members of the faculty of the first medical school in the Colonies, rivals, the latter pictured as a grafter, "a man of cool malice and treachery"; Benjamin Rush who in spite of his blood-letting and purges was a great physician as well as an influential political and social leader; Ephraim McDowell, pioneer surgeon of Danville, Kentucky, who, for the first time, opened the abdominal cavity and removed a huge ovarian tumor, while the mob outside waited with a noosed rope to string him up for murder if his patient died; Daniel Drake, founder of a great medical school in what is now the mid-west, then the frontier; William Beaumont, army surgeon, who, in backwoods forts investigated digestion in the stomach of Alexis St. Martin, opened to inspection by an accident; Crawford W. Long and William T. G. Morton who first used ether as an anaesthetic.

Striking as these portraits are their backgrounds are even more vivid. One marvels that the patriot army in the Revolutionary War could win out when incompetence and greed made its death rate from disease twenty times that of its British opponents. The picture of Philadelphia in the grip of the yellow fever epidemic of 1793 is so lurid it dims that of Rush, the tireless doctor.

Here are heroic figures to goad red-blooded men to new achievements in the art of healing—none the less heroic because they are very human. The book is well worth reading. It might inspire some youngster to a life of rare service. —E.R.D.

PETERSHAM, MAUD AND MISKA. *The Story Book of Aircraft.* Chicago: The John C. Winston Company, 1936. 32 p. $0.60.

This is a story of the history of aircraft, simply and interestingly written, each page illustrated beautifully in rich and attractive colors. It begins with the legend of Icarus and ends with recent achievements. It is an excellent book for use in the elementary school. —L.M.S.

PETERSHAM, MAUD AND MISKA. *The Story Book of Wheat.* Philadelphia: The John C. Winston Company, 1936. 31 p. $0.60.

This is a fascinating story about wheat from wild wheat to the improved wheat of modern times. The story is arranged in short paragraphs with large print and a goodly part of the page is devoted to an illustration of the story in delightful color drawings. The book is excellent for lower grade work in geography and science. —L.M.S.

MORGAN, ALFRED. *An Aquarium Book for Boys and Girls.* New York: Charles Scribner's Sons, 1936. 180 p. $2.00.

This is a splendid book for use in schools or in the home. The making, stocking and maintenance of aquaria, including many details and problems which perplex one who wishes to keep aquaria are discussed in an interesting and practical way. There is a chapter on the collecting and keeping of wild fishes locally, also chapters on the care of amphibians, turtles and alligators in vivaria. The book has useful illustrations. —L.M.S.

PALMER, E. LAURENCE. *Nature Magazine's Guide to Science Teaching.* Washington, D. C.: American Nature Association, 1936. 128 p. $1.00.

This is a suggested course of study in science for the first ten years of school with recommendations for each grade and specific page references to material found in *Nature Magazine.* In addition to the valuable aid to teachers in planning a course of study, the organization of the splendid material available in *Nature Magazine* over a period of years is a special help which teachers will welcome. The book presents a technique for the use of supplementary material. —L.M.S.

BAWDEN, ARTHUR T. *Man's Physical Universe.* New York: The Macmillan Company, 1937. 812 p. $3.50.

This is a survey course in physical science giving the student an overview of physics, geology, astronomy, and chemistry. It is a book of breadth rather than depth of treatment and yet it is a work of high standard which will stimulate the average student to further study. There are 368 illustrations. Each section is followed by an appropriate list of "study questions" and a fifteen page bibliography is at the end of the book. —W.G.W.

JOHNSONS, ARTHUR T. *Sound.* New York: D. Van Nostrand Company, Incorporated, 1937. 450 p. $3.75.

While this is a college text, it contains so little mathematics and so little technical matter that anyone with little or no previous physics background can profit by its study. It gives a splendid background of speech and music. There are hundreds of questions throughout the text whose purpose is to stimulate thought. There are 141 illustrations. —W.G.W.

EYRING, CARL F. *A Survey Course in Physics.* New York: Prentice-Hall Incorporated, 1936. 378 p.

This book is the outgrowth of eight years' trial use. The human body and its physical environment are made the central theme. It is adapted particularly to the needs of non-science students. It may be covered in one-quarter year but a whole semester may well be devoted to it. The book is interestingly illustrated and is comparatively free from mathematical treatment. It is a book that will be welcomed by any college student. —W.G.W.

GATTERMAN, L. *Laboratory Methods of Organic Chemistry.* New York: The Macmillan Company, 1937. 425 p. $4.50.

When a book can continue through twenty-four editions over a period of more than forty years its merit is undenied. So we welcome this new translation of Gattermann-Wieland which makes available for both student and research man the most efficient and modern methods of organic technique and the theory involved in the preparative reactions. No student of organic chemistry can afford to be without this text. —Alvin Strickler.

ROBINSON, C. ROSS. *Laboratory Practice of Organic Chemistry.* New York: The Macmillan Company, 1937. 326 p. $2.25.

Part I of this book is largely theoretical with a good many questions and problems that assist in the clarification and fixation of the topics discussed. Part II is the practical section and contains, besides the regular synthesis, a few qualitative and quantitative problems. Most of the preparations are standard with only "a few novelties." The directions are concise and well arranged. The type is clear and the style good. The author is obviously interested in good teaching and the book is to be highly recommended to all good teachers of organic chemistry.

—Alvin Strickler.

KOLTHOFF, I. M. *Acid Base Indicators.* New York: The Macmillan Company, 1937. 414 p. $7.00.

This book is a translation of the 1932 German edition of Kolthoff's *Saure-Basen Indicatoren,* with "an omission of the section on neutralization curves and some minor additions and revisions of the translator." It makes available in English one of the outstanding books in this field, a worthy companion to the author's *Volumetric Analysis* and his more recent *Textbook of Inorganic Quantitative Analysis* written in collaboration with E. B. Sandell (pub. 1936).

Part One deals with "The Dissociation of Strong and Weak Electrolytes." Part Two discusses "The Properties of Acid-Base Indicators," and Part Three "The Colorimetric Determination of Hydrogen Ion Concentration." The appendix includes various tables of particular value, the most important being Table 4, "Dissociation Constants of the Most Important Acids and Bases," and Table 5, "Transformation Ranges of the Most Important Indicators."

It is interesting to note how up-to-date the book, although written in 1932, actually is. The reader will find the discussion and approach to the ion activity theory and to the Brönsted concept of acids and bases especially significant and readable. The sections on "Colorimetric Determination of pH" are well organized and detailed so that a student would have no difficulty in actually carrying out the experiments. Of considerable value is the discussion of "The Sources of Error in the Colorimetric Method" for this is fundamental in all analytical determinations. References are numerous and good. The figures are clear and well chosen. The type is clear. The author's style is interesting and appealing. —Alvin Strickler.

WILLIAMS, SAMUEL R. *Foundations of College Physics.* Boston: Ginn and Company, 1937. 630 p. $4.00.

In this new text the author, apparently influenced by many recent books which emphasize the cultural and descriptive phases of physics, has followed a middle course. An attempt has been made to make the book interesting, and yet the mathematical approach has by no means been slighted, for as the author says, "Physics is physics."

The book is divided into the traditional units: Mechanics, Sound, Heat, Electricity and Magnetism, and Optics. The introduction contains useful study and problem solving suggestions. Each section is preceded by a graphic outline of the material to be covered. Each chapter is followed by a very short summary of important points and a set of problems. An unusually complete appendix contains a number of mathematical tables, as well as an excellent set of tables of various physical constants.

A departure from traditional terminology is the use of the term "negatron" to denote a small negatively charged particle. This should assist the student in remembering the polarity of the "electron."

A working knowledge of algebra and trigonometry are necessary to fully appreciate this book.

The author is to be commended for lessening the student's confusion by employing, almost exclusively, the cgs system of units.

The drawings, cuts, type and binding are all good.

This book would hardly be suitable for a cultural course but is recommended as an excellent text for laying a groundwork in physics for those who are majoring in science.

—P. E. Hatfield.

PARTINGTON, J. R. *A Text-Book of Inorganic Chemistry.* New York: The Macmillan Company, 1937. 1062 p. $4.60.

This is the fifth edition of a standard English text. It is intended for use in advanced courses in inorganic chemistry. For the beginning student in inorganic chemistry it will make an excellent reference book. Even the student of physical chemistry will find much of value; this is especially true of the material on crystallography.

A large number of industrial processes are described but many of them are used only in Europe and are of limited interest to us. Each chapter has a group of experiments included in it. Fourteen of the chapters, which includes most of those on various phases of physical chemistry, are followed by summaries. It would have been quite difficult for the author to summarize the chapters which are largely descriptive due to the mass of material found in them. Forty-three pages of questions and problems on the various chapters are included in the back of the book. The answers to the problems are given.

The only criticism which one can make is one which applies to many English chemistry texts. A somewhat less confusing arrangement of the enormous amount of material included in the text could be wished for.

—P. E. Hatfield.

SPINNEY, LOUIS B. *A Textbook of Physics.* New York: The Macmillan Company, 1937. 721 p. $3.75.

This is the fifth edition of a widely used college text. The author's aim has been "to emphasize the practical aspects of the science, to illustrate the laws of physics as far as possible by reference to familiar phenomena, and to exemplify principles by discussing their applications."

The book is divided into five parts: Part I, Mechanics; Part II, Heat; Part III, Magnetism and Electricity; Part IV, Sound; and Part V, Light. This edition contains several new chapters, among them one on electron tubes. In addition the chapter on electromagnetic waves has been revised. In connection with this the author errs when, on page 497, he states that "The set-up used in broadcasting ise essentially the same as that required for the wireless telephone, except that larger oscillators are used. . . . The oscillating tube generators are of great size, and sometimes a number of them are operated in parallel to increase the output." This practice of using high-power oscillators in radiotelephony has been obsolete for years. Neutralized amplifiers are used to build up the power output.

Most of the chapters are followed by problems. A very short appendix contains a table of trigonometric functions. The drawings, type and binding are all good.

—P. E. Hatfield.

MILLIKAN, R. A., MERRIAM, JOHN C., SHAPLEY, HARLOW, AND BREASTED, JAMES H. *Time and Its Mysteries.* New York: New York University Press, 1936. 102 p. $2.00.

This small volume consists of a series of four lectures given under the James Arthur Foundation at New York University from 1932 to 1935. Titles of the lectures are as follows: "Time"; "Time and Change in History"; "On the Lifetime of a Galaxy"; "The Beginnings of Time-Measurement," and the "Origins of Our Calendar." The lectures are given in the order of their lecturers, as authors, in the title above.

In each of the lectures the concept of time is treated primarily from the point of view of the special interest of the lecturer; that of Dr. Millikan gives the physicist's view of time, that of Dr. Merriam, the geographer's, that of Dr. Shapley, the astronomer's, and the lecture of Dr. Breasted the concept of the historian. The names of the authors make sufficient guarantee of the value of the presentations.

These lectures are readable. The educated layman need have no fear of a multiplicity of technical terms. The reader can be assured that a perusal of these lectures will leave him with an expansion of his older notions of time. The volume is recommended to the general reader and, especially, to the teacher of science or of history. It can be read by many senior high-school pupils and is recommended for the college library.

—R.K.W.

NEEDHAM, JOSEPH. *Order and Life.* New Haven: Yale University Press, 1936. 175 p. $2.50.

This is a group of Terry Foundation Lectures given at Yale University in 1935. The titles of the three lectures are: The Nature of Biological Order; The Deployment of Biological Order, and the Hierarchical Continuity of Biological Order. The author is a biochemist from the University of Cambridge.

The lectures are primarily concerned with the essential unity of all biological organisms, and more especially with the essential unity of all science, both biological and physical. Much of the initial material is basically philosophical. The significance of the concepts for religion are implied rather than explicitly stated.

The book will be thought provoking for students of considerable biological and philosophical training.

—R.K.W.

HURST, C. C. *Heredity and the Ascent of Man.* The Macmillan Company, 1937. 138 p. $1.50.

For the general reader possessing little knowledge of the facts usually presented in an introductory course in college biology, this little book gives an account of the principles of heredity based on recent research studies in genetics. There are short chapters on such subjects as the gene, the gene complex, the laws of heredity, how evolution progresses, the ascent of man and mind, etc. It is a coherent summary also for readers who have not thought of the subject recently.

Few biologists would agree with the author in his optimism with regard to the possibility of

man, through this knowledge, becoming "master of his own fate," but a pleasant and profitable evening's reading is offered for one wishing to secure information about genetics written by a prominent geneticist in brief and popular style.

—Caroline Stackpole.

MCCLENDON, J. F., AND PETTIBONE, C. J. V. *Physiological Chemistry.* St. Louis: The C. V. Mosby Company, 1936. 454 p. $3.50.

A college textbook in physiological chemistry written in orthodox style. In this new (sixth) edition all chapters have been reorganized or entirely rewritten. Three chapters new to this edition are given to the discussion of enzymes, energy exchange and internal secretions. The material given under these headings is in each case confined to fundamentals, and as in all chapters throughout the book, gives no greater array of facts than may be considered basic knowledge of physiological chemistry. The book becomes, therefore, a usable text.

Laboratory exercises designed to cover the field of the text occupy about a hundred of the pages. The results of recent experience in handling laboratory methods have been used to simplify the experiments selected. For example, the use of the Duboscq colorimeter as introduced by Folin permits analysis of a single drop of blood rather than requiring the larger amount of blood usually used. A finger prick rather than puncture of a vein simplifies this work greatly, and the smaller quantity of blood saves both time and reagents. This is true also in analyses by colorimetric and volumetric methods rather than by the usual gravimetric methods. This attempt to simplify is evident in the arrangement of all the experiments outlined.

—Caroline Stackpole.

MATHEWS, ALBERT P. *Principles of Biochemistry.* Baltimore: William Wood and Company, 1936. 512 p. $4.50.

This is a completely new book written by the author of the well-known Textbook of Physiological Chemistry and is in no sense a revision of the older book. It is offered as a textbook in biochemistry to medical students, who are, the author believes, too busy to include in their programs a course using the larger text. From his experience as a teacher of the subject for many years, the author has come to believe that medical students may profit by having the significance of the facts of biological chemistry made easy to grasp. These students must be grateful to Dr. Mathews for sharing with them his knowledge, insight, and experience through the clear simplicity of his writing. The easy literary style is a large item in making his principles of biochemistry "easy to grasp."

The first chapter is entitled "The Importance of Biochemistry in Medicine." In it Dr. Mathews says, "It is our ignorance of the chemistry of the human body which particularly retards the development of medical science." He says, too, that his purpose has been "to correlate and synthesize the numerous facts so that they will appear, not as an inchoate assembly of facts, but as making part of a great science which reveals the finer structure and coordinated chemistry of the human body." Following this chapter are sections on the chemistry and metabolism of the carbohydrates or glucosides, the fatty substances or lipides, the proteins or protides, the special chemistry of important tissues as blood and connective tissues, the vitamins and hormones, the catalytic agents of growth and development, and energy metabolism.

There are few references to recent literature in the text but the preface contains a fine list of the reviewing and abstracting journals and of some of the recent books.

This short text is equally valuable to all teachers of science, both from the viewpoint of its subject matter and as an example of conciseness and clarity of exposition.

—Caroline Stackpole.

STROMSTEN, FRANK A. *Mammalian Anatomy.* Philadelphia: P. Blakiston's Son and Company, 1937. 328 p. $3.00.

This sixth edition of Dr. Stromsten's very well-known combination textbook and laboratory manual of basic mammalian anatomy shows many changes from earlier editions. These changes are definitely planned to fit the book to the needs of the increasing number of students who are majoring in such fields as Education, Natural Science Education, Experimental Biology, Physiology, Psychology, and Physical Education and who need a good knowledge of comparative anatomy. As the subtitle indicates, the main descriptions refer to the cat; there are, however, constant comparisons to the various laboratory animals and to man.

There are 172 illustrations, or something more than one illustration for every two pages. Some of these have been redrawn from earlier editions and many, drawn from dissections or borrowed from reliable and credited sources, have been added. Often the detailed descriptions accompanying the illustrations have been shortened and nearly every structure mentioned in the text has been shown in some figure. Such illustrations with concise descriptions help the student greatly. The plan of calling attention to variations in anatomical details such as the persistent jugular lymph sac found by the author in one specimen is desirable. Too often students fail to realize the frequency of variations in the location or structure of organs and become puzzled by them in dissections.

Several sections of the text have been considerably enlarged, and there are a number of minor changes and corrections. Each chapter is followed by a section called Laboratory Studies and Suggestions. These sections contain questions and directions for describing the laboratory dissections. There is an extended

glossary. The preface gives reference to many useful books and papers on mammalian anatomy.
—Caroline Stackpole.

Westfall, Byron Lee. *Educational Opportunities in Missouri High Schools.* Columbia, Mo.: University of Missouri, 1937. 190 p. $1.60.

The investigation reported here is a comparative study of eighteen high schools in Missouri. The high schools varied in enrollment from 30 pupils to 2,812 pupils, and ranged in teaching staff from two, to one hundred and one teachers. All were officially rated by the State Department of Education as first-class high schools. Consequently, it is inferred by the author that the small schools studied were almost certainly better than the average high school of similar size, while the larger ones are believed to be more typical. Actual disparity between smaller and larger schools would probably be even greater, therefore, than appears to be the case here. Preliminary information was secured by correspondence and then each school was visited by the author. Additional data were gathered from record forms of the North Central Association of Colleges and Secondary Schools, which were filled out by each cooperating school. The findings are reported in tabular form but the main part of the report consists of descriptions of each school covering among other items, such things as community facilities, physical plant and equipment, library, science laboratories, teaching and administrative staff, program of studies and extra-curricular activities, provisions of health, educational guidance, cost per pupil, fees and other expenses paid by pupils, and record systems. The results show a consistent and marked improvement in relation to size of enrollment, the larger schools always being superior to smaller ones. The only possible exception is in the largest group where it is not so clear that the school of 2,812 pupils is any better than the one of 1916 or that of 2,078. But the superiority of each successively larger enrollment group over the preceding ones is unmistakable. Per-pupil costs are also greater in the small high school than in larger ones.

As the author points out, this does not answer all the questions that may be raised. The optimum size for a high school is still not known, nor is it known just where smaller enrollments begin to be a serious handicap. Furthermore, the problem of making the marking of the small high school as good as a large one, without consolidation, is perhaps the most important and a challenge to the best constructive work of which educators are capable.

The author has made an illuminative and informative study, and reported it in an interesting readable manner. It is often difficult to realize that a large number of high schools in this country are so inadequate and poor. This report brings the facts forcibly to mind. —V.H.N.

Eastwood, Cyril G. *A Handbook of Hygiene for Students and Teachers.* Baltimore: William Wood and Company, 1936. 358 p. $2.50.

This book is an outgrowth of the experiences of the author in public health work and of successful teaching of courses in physiology and hygiene in the Education Department of the University of Leeds and at the City of Leeds Training College. It is intended primarily for those who are trained to teach or who are already engaged in teaching. The author emphasizes the physiological approach which he says is necessary for a proper understanding of the principles of hygiene. The book is divided into six parts which treat respectively the following matters: (1) The elements of biology, giving special emphasis to general anatomy and physiology of the human body; (2) Nutrition and dietetics; (3) The application of this knowledge in maintaining health; (4) Common diseases that cause ill health among children; (5) Hygiene as it affects groups of children rather than individuals; (6) Heredity, the teaching of hygiene, and Acts of Parliament relating to children and education.

The book is illustrated by line drawings and a few appropriate photographs. A vocabulary of technical terms is included. —F.G.B.

Blair, Thomas A. *Weather Elements.* New York: Prentice-Hall, Inc., 1937. 401 p. $5.00.

Teachers of survey courses and courses in weather and climate will welcome this scholarly authoritative work by a meteorologist who has spent more than thirty years in the service of the United States Weather Bureau. There are 107 illustrations—maps, charts, graphs, diagrams and photographs. Two excellent series of photographs are those of a tornado and ball lightning discharge. Practical problems and exercises are found at the end of each chapter.

Some of the chapter headings are: (1) The atmosphere; (2) Observing temperature, pressure, and winds; (3) Observing moisture; (4) Interrelations of temperature, pressure, and wind; (5) The general circulation; (6) Weather forecasting; (7) World weather; (8) Climate; (9) Climate and man; and (10) The United States Weather Bureau.

Personally, the reviewer would have welcomed a chapter on world and United States weather records—*e.g.*, greatest snow-storm; coldest winter; lowest and highest temperature; largest fall of hail; and so on. But altogether it forms a splendid reference on weather and climate.
—C.M.P.

Anonymous. *Savings and American Progress.* Chicago (221 North La Salle Street): Allied Products Institute, 1937.

This interesting pamphlet discusses the relation of wealth-creating enterprise to employment and the American standard of living. Many interesting conclusions are drawn. Increased consumer purchasing-power is essential to greater business and industrial profits as well as to a higher standard of living. Without savings, American business can make no progress, nor can present standards of living be raised or even maintained. —C.M.P.

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